Journal and Proceedings

OF

The Royal Society of Western Australia.

PATRON: HIS MAJESTY THE KING.

Volume VIII

1921 - 1922

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1922.

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ROYAL SOCIETY OF WESTERN AUSTRALIA.

Statement of Receipts and Expenditure for the year ended the 30th June, 1922.

RECEIPTS.	£ s. d.	£ s. d.	EXPENDITURE.	£ s. d.
Subscriptions—				
1918–19...	0 10 6		Fees to Museum ...	14 14 0
1919–20...	2 2 0		Govt. Printer for Vol. VII. (on account) ...	77 14 5
1920–21...	13 2 6		Govt. Printer for cards, etc.	8 11 9
1921–22...	76 18 0		Postage and Petty expenses	10 11 9
1922–23...	11 11 0	104 4 0		
Interest		0 14 0		
Fees for reprints		6 11 0		
Books sold		0 10 0		
Total receipts ...		111 19 0	Total payments	111 11 11
Balance in hand on 1st July, 1921—			Balance in hand on 30th June, 1922— £ s. d.	
In Bank ...	1 6 9		In Bank ... 1 18 3	
In cash ...	1 19 2	3 5 11	In cash ... 1 14 9	3 13 0
		£115 4 11		£115 4 11

Amount still owing to Government Printer:—

	£ s. d.
For Vol. VII.	6 7 9
For cards	1 12 6
	£8 0 3

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Hon. Treasurer.

Examined and found correct,—

(Sgd.) F. B. CREETH.

(Sgd.) A. R. GALBRAITH.

6th July, 1922.

PROCEEDINGS OF THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

12*th July,* 1921.—The President, Dr. E. S. Simpson, in the Chair. The annual report of the Council was read and adopted, and officers elected for the ensuing year. Dr. E. S. Simpson delivered the Presidential Address on "Science and the Mineral Industry." Mr. W. B. Alexander, M.A., gave an account of his collection in South America of the natural enemies of the Prickly Pear.

Messrs. D. A. Herbert, M.Sc., and J. Clark urged the formation of a Field Naturalists' Section of the Royal Society, and it was agreed that the Excursions Committee should submit proposals to the Council.

9*th August,* 1921.—The President, Mr. F. E. Allum, in the Chair. The President extended a welcome to Dr. Baldwin, who, in replying, outlined the nature of his work in the Eastern States and also his proposed activities in this State in connection with the Hookworm investigation. Professor Ross read a paper on "Taxation, with particular reference to Commonwealth Taxation." The President, Mr. F. E. Allum, Dr. Simpson, and Mr. Watkins took part in the ensuing discussion.

13*th September,* 1921.—The President, Mr. F. E. Allum, in the Chair. Mr. L. Glauert, F.G.S., exhibited—

(a) *Psilocephalus,* from the neighbourhood of Dongarra, a fish related to the leather-jacket, and found formerly off the coasts of India.

(b) *Lactophrys sp.,* a fish hitherto not recorded from Australia.

(c) Shells of *Voluta Nivosa* from Cottesloe. Not found previously south of the Abrolhos Islands.

Dr. D. D. Paton delivered an address on the "Evolution of the Eye," illustrating it with drawings, lantern slides, and stereoscopic photographs of portions of the eye.

12*th October,* 1921.—The President, Mr. F. E. Allum, asked His Excellency the Governor to take the Chair. Mr. G. L. Sutton then read a paper on "Pedigree Culture of Wheat," giving an account of pure line selection as carried out at the Chapman and Merredin Experimental Farms. Lantern slides effectively illustrated the lecture.

8*th November,* 1921.—The President, Mr. F. E. Allum, in the Chair. Mr. L. Glauert, F.G.S., exhibited *Pterodroma mollis* and *Halobaena coerulea,* additions to the avifauna of Western Australia. Mr. Glauert also exhibited living specimens of *Notomys gouldi,* a pouched mouse from the Nullarbor Plains. Mr. A. R. Galbraith, M.I.C.E., read a paper on "Zanzibar," outlining its history, geology, fauna, flora, and agriculture. Interest attached to the possibilities of the future when the agriculture of Zanzibar would receive scientific direction.

13*th December,* 1921.—The President, Mr. F. E. Allum, in the Chair. Mr. L. Glauert read a paper on "New Specimens in the Western Australian Museum," and communicated for Mr. Edwin Ashby, of South Australia, a paper on some West Australian *Acanthopleura.* Mr. D. A. Herbert, M.Sc., read a paper describing several new species of West Australian plants. He also presented and read a description by A. Cayzer and F. W. Wakefield of *Darwinia pimelioides;* and Mr. W. H. Shields, B.Sc., C.E., read a paper on "Some Traits of the West Australian Aboriginal," illustrating it with lantern slides.

The President, on behalf of the Society, expressed the regrets of members at the approaching departure of the Hon. Secretary (Mr. D. A. Herbert, M.Sc.), and took opportunity of the occasion to present Mr. Herbert with a token of the esteem in which he was held.

14*th March,* 1922.—The Vice-President, Mr. E. de C. Clarke, M.A., in the Chair. Messrs A. Gibb Maitland, E. de C. Clarke, Professor Whitfeld, Dr. Simpson, and Professor Wilsmore, dealt with "Petroleum or Rock Oil," considering it from aspects of distribution on the earth and political importance, geological conditions for storage, technology of oil drilling and recovery, chemistry of oils, and theories of origin.

11*th April,* 1922.—The President, Mr. F. E. Allum, in the Chair. Mr. L. Glauert exhibited a model of the nest of *Notomys gouldi,* and Mr. H. Steedman exhibited various rock and mineral specimens from the Kimberleys, and these were described by Mr. E. de C. Clarke. Professor G. E. Nicholls, D.Sc., then read a paper on "The Variation in the Vertebral Column in the Anura," illustrated by lantern slides, and conveying the results of investigations extending over many years. Dr. Simpson and Messrs. Allum, Hancock, Shelton, and Steedman took part in the discussion.

9*th May,* 1922.—The President, Mr. F. E. Allum, in the Chair. Mr. R. D. Thompson, M.A., M.Sc., delivered an address on "The Solar Eclipse of 21st September, 1922," illustrated by means of maps and lantern slides. Mr. Farquharson read a paper on "The

Occurrence of Impsonite in West Australia." Special interest was aroused in matters pertaining to the oil possibilities of this State. The minerals described were exhibited by Mr. Farquharson. It was announced that the Annual Conversazione would be held at the University on the 27th May.

13th June, 1922.—The President, Mr. F. E. Allum, in the Chair. It was determined that there be two joint secretaries in future, one for Physical Science and one for Natural Science, and the necessary alterations were made in the rules of the Society. The President, Mr. F. E. Allum, delivered his Presidential Address, taking as his subject "Modern Currency Problems."

Note.—The paper on "The vertebral column of the Anura," which was delivered by Professor Nicholls on the 11th April, 1922, was an interim report on a long series of observations. He intends to place the full results of his work on this subject before the Society in 1923. The completed paper should therefore appear in Vol. IX. of this Journal.

THE JOURNAL

OF

THE ROYAL SOCIETY

OF

WESTERN AUSTRALIA.

VOL. VIII.

Presidential Address.

MODERN CURRENCY PROBLEMS.

Presidential address by F. E. Allum, delivered on 13th June, 1922.

In 1915 I read a paper before this Society on "Principles of Currency." In that it was shown that the principles laid down by Lord Liverpool in his letter to King George III., dated 7th May, 1805, had proved in practice to be sound, and that their adoption by the British Government in 1816 had put an end to currency troubles which had long distracted the country and hampered the expansion of its trade. The system was so simple, and worked so well, that by the beginning of the 20th century it seemed to most people to be merely natural and obvious. Few knew anything of the long period of chaos and loss which preceded its adoption. The basic feature was the selection of one commodity as the standard of value, and the expression of all values in terms of that standard. All other instruments of exchange, whether of metal or paper, to be subsidiary. Metallic tokens to circulate at so much more than their intrinsic value that profit could not be made by melting them. The standard recommended by Lord Liverpool was gold. The actual standard adopted in 1816 was 113 grains of pure gold, called a pound or sovereign, and issued for currency in the form of a coin weighing 123.27447 grains, of which 10.27447 grains were to be composed of alloying metal. The value of this alloying metal is not taken into account in reckoning the currency value of the coin. The currency value is the value of the gold only. (It may here be mentioned that in the early issues of sovereigns from the Sydney Mint silver was used as the alloy. In all other sovereigns the alloy has been copper.)

Standard of Value.

A thing possesses value only when somebody wants it. The degree of that want can be measured by the amount of some thing which the person is willing to offer in exchange. Values can therefore be expressed in terms of any commodity other than that of the thing desired. To facilitate the myriad exchanges of goods and of services, which are constantly taking place, it is convenient to measure all values in terms of one commodity only, that is to say, to fix upon one concrete object as the standard measure.

Values have been thus reckoned in terms of cattle, rum, sugar, wheat, beads, and a hundred other things at different times and places. The selection of gold in 1816 as the standard of value for Great Britain was the result of a long series of natural eliminations. It was chosen for its important physical properties, and because the demand for it, and the supply of it, being free from violent fluctuations, it had great stability of value. Gold is equally suitable for a medium of exchange as for a standard of value, because it can be divided without loss of value, is not subject to rust or decay, and is practically indestructible, while its small bulk in relation to its value makes it more portable than other available materials.

The question is often asked why so much regard is set on the possession of gold. The answer is that, wisely or not, human beings want it, just as they want pearls and diamonds, and in each case the want creates the value.

The use of gold as currency absorbs a large portion of the output of the mines, and by increasing the demand must also increase the value.

Jevons says that a unit of value "must consist of a fixed quantity of some concrete substance defined by reference to units of weight and space. Value may seem to some people to be a purely mental phenomenon, and a pound would then have to be defined . . . . by a sense of value. But we might as well define a yard by a sense of length or a grain by a sense of weight. Just as every quantity in physical science is defined by reference to some concrete standard specimen, so, if we are to measure and express value at all, we must fix upon definite quantities of one or more definite and unchangeable commodities for the purpose."*

When a standard of value has been chosen there will sooner or later be a tendency to regard it as something which does not alter in value. This pitfall must be avoided. It is doubtful whether anything in the world can remain at exactly the same value from one day to the next.

Before the great war all the chief commercial countries (except China) had to some extent followed the British lead, and adopted a gold standard, or one partly based upon gold. Great

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* Money, by W. Stanley Jevons, p. 68.

Britain was, however, the only country where every kind of instrument of exchange could be turned into gold if required. The holder of a Bill of Exchange, for instance, could first get credit at his Bank, either by discounting the bill or waiting till it matured. He could then draw a cheque on his Bank, receive payment in Bank of England notes, and the notes could be exchanged for gold on demand.

Someone was always wanting either to buy or sell in London, and an enormous bill discounting business grew up there in consequence. Bills on London were readily accepted all over the world, and this was due in the first place to the good reputation of the accepting houses; secondly, to the stability of the currency resting as it did upon gold, but ultimately on the volume of trade.

If A had to receive payment for goods exported, B had to make payment for goods imported. All trade is at bottom barter—exchange of one thing for another—and so long, therefore, as the imports and exports remained at about the same total value, the Bill discounters and Banks could satisfy everyone without gold being moved at all. When this desirable equilibrium was lacking the excess of imports or exports was balanced by the transfer of gold. That is to say, when debts could not be paid in goods they were paid in gold. It must, however, be remembered that gold is in no essential way different from any other commodity, and that what really happened was that a reserve store of wealth was called upon. The effect would have been just the same if that store had been of iron, potatoes, or any thing whatever, so long as the creditors were willing to receive it.

Prior to 1816 Hamburg and Amsterdam were the principal money markets of the world. Subsequently the certainty that debts due in London would, whenever demanded, be paid for in a metal which would find eager buyers in every commercially civilised country helped to transfer this pre-eminence to London. British currency was composed of gold, or paper and coins which could always be exchanged for gold. In no other country was this actually and always the case. For some years before the war it was theoretically so in Germany and in the United States, but difficulties were placed in the way when the Government or the Banks deemed it inadvisable to let the stock of gold be depleted. France reserved the right to pay in silver 5-franc pieces, and no other country attempted to have a currency always exchangeable for gold. India, Japan, Brazil, Argentina, and Mexico have what is called the gold exchange system, by which there is a fixed rate at which they will buy gold with their own currency, but they do not undertake to part with gold in the same way. China is the only large silver-using country.

This was the position prior to August, 1914, and it was one which gave Great Britain a grasp of the monetary affairs of the

world which none could take away. Nothing at that time seemed more improbable than that Great Britain would ever again be faced with serious currency troubles. The financial machine, however, although it worked with ease and precision, was complicated and delicate, and, like so many other arrangements, broke down under the strain of war time conditions.

Paying for War.

Vast sums of money were raised, partly by taxation and partly by loans. Money also appeared to be made out of nothing by the issue of inconvertible notes. At first there was a large stock of gold coin (estimated in Great Britain at about £100,000,000) in the pockets of the people. This was gradually removed through the medium of the Banks and sent abroad to pay for munitions of war. It was replaced by a new form of currency—Treasury notes. Sums invested in foreign countries, particularly in the United States, were withdrawn; the capital thus released being used to purchase food and munitions in those countries.

As the present monetary chaos in Europe, and our own relatively small, but serious difficulties, are the results of war time finance, it is desirable to consider the way in which countries have provided for the cost of the war.

War is conducted by means of men, guns, horses, ships, railways, aircraft, etc. All these must be of the best kind, and the men must be trained, and the munitions provided, in the shortest possible time. A country at war is then and there the poorer to the extent of all the lives lost, and all the material used, as well as by the cessation of commercial production and expansion. The problem of paying for the war is really the question—How shall the Government apportion this loss among the people? Clearly the simplest way is by direct taxation. Loss due to a small war is easily met out of current taxation and accumulated stores. In the case of a great war these are not enough. Direct taxation sufficient to raise the whole sum brings with it such an immediate realisation of the appalling loss that is going on that the country would be inclined to stop fighting. If national existence is at stake this cannot be permitted, and Governments take the easier way of raising loans. This may seem to be the only practicable way. It is none the less a bad way, because the money is ultimately subscribed three times over. First it is subscribed by those who take up the loan, and are then and there the poorer to that extent; secondly, by the taxpayer who has to provide the money to pay the interest on the loan, and thirdly, by the taxpayer again when the loan is repaid. It is bad also because it gives a sense of having handed some of the burden on to posterity. Posterity, however, cannot pay for the war. The war has already been paid for in men and things destroyed, and all of

us are the poorer for it. Loans are a comforting opiate. They do not improve the situation. Indeed they make it worse. Mr. Hartley Withers (late Editor of the London "Economist") has written fully on this matter, and has, I think, proved beyond all question that by no manner of means can we pass on to posterity the burden of paying for the war. We can and do pass on an impoverished estate, and we hand on the obligation to repay both interest and capital to the descendents of those who lent the money, but the products of our descendents will be theirs to consume. By no financial magic can posterity really be made to lighten the burden of our actual loss.

*Withers writes:—"It is commonly said that we are still, as a nation, paying off the cost of the war that our ancestors waged against Napoleon more than a hundred years ago. But this is not so. As taxpayers we pay interest on the debt then raised. But we pay that interest to those of us who hold the debt by inheritance or otherwise. As a nation we enjoy now all that we produce, and the vagaries of our ancestors only affect the manner in which our production is distributed."

Germany was so sure of winning the war, and recouping herself out of indemnities, that from the very first she paid her way with borrowed money. Apart from the trouble that this policy must eventually bring upon Germany, it led people in Great Britain, and other lands, to indulge in a self-righteous pride in not being as bad as Germany, while all the time they were treading the same road. It is true, and is a matter for much congratulation, that Great Britain provided more of her war costs out of current revenue than any other European country, but even she raised loans on a very large scale, and some of them quite early in the war at a time when many people were asking to be taxed in order to save their country.

Inflation with inconvertible notes.

The money handed to the Government, whether as taxes or as contributions to a loan, was not in hard cash. That had already gone. People transferred some of their credit at the Banks to the Government by means of cheques, and the Government, when spending the money, made payments in notes. These had to be received as legal tender for any amount, just as if they were gold, although no promise to redeem them in gold was made.

Thus the gold standard was abandoned and the British currency became composed of paper partly supported by gold and partly by the future taxable capacity of the people. When inconvertible notes are used there is always uncertainty about the number which will eventually be issued. The ultimate value of the currency is thus doubtful. No one knows what the paper pound will buy in the

* Hartley Withers, "Our Money and the State," p. 40.

future, and risk is run in making contracts for any time but a very short one. The circumstances become something like those of the bad old days of the 17th century, about which *Mr. Lowndes, the Secretary of the Treasury, writing in 1695, said that "in consequence of the defective state of the silver coin contention daily arose. . . . . . in fairs, markets, shops, and other places throughout the kingdom to the disturbance of the public peace, that many bargains and dealings were totally prevented and laid aside, which lessened trade in general; that persons before they concluded any bargain were necessitated first to settle the price or value of the very money they were to receive for their goods."

Although war time conditions practically compelled the use of paper money, it was none the less unfortunate in its results. A mass of paper money masquerading as gold has the same effect on prices as if it were gold. Let us for a moment consider what would be the effect of a sudden flooding of the world with an immense supply of gold coin. The metal being very plentiful would become cheap, and people would have to offer more of it in exchange for whatever else they wanted. That stability of value, so essential in the chosen standard of value, would be gone. Whether vast additions to the currency are made by the issue of more coin, or by the issue of paper purporting to be coin, the effect is the same. The United States is suffering from inflation of the currency, not because of the issue of notes, but because of the enormous accumulation of gold which they have received in exchange for munitions of war, etc., and which cannot now be again exchanged for goods because so many countries are ruined, and have no goods to put on the market.

The fact that the volume of currency affects prices is perhaps more easy to see if we suppose, for the moment, a currency of wheat —an old time standard of value. In a year of bountiful harvest nature would have inflated the currency. Wheat would be both pentiful and cheap. More of it would have to be offered in exchange for other things. That is to say, prices (expressed in bushels of wheat) would be high.

Considerations of the conditions which would arise with a very variable standard like that of wheat, brings the good points of the gold standard, with its relatively minute variations, into strong relief. How can trade be conducted if the measure of value is itself always changing in value? Present small bargains may be arranged, but what about big contracts running into years? What indeed about the future repayments of loans to the Government, of provision for old age, or dependents, by life insurance, or any deferred payment whatever? When none can tell what will be the real value of sums to be paid or received in the future, no one can safely enter into contracts. Fear of loss must paralyse trade.

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* Liverpool, "Coins of the Realm," p. 80.

The issue of inconvertible paper money opens the door to endless inflation of the currency. In the old days people suffered so much through "debasement of the coinage," that a wholesome dread is aroused at the sound of the very words. Paper money, however, can effect a greater debasement than could be brought about by the most dishonest monarch of olden times. He might reduce the content of his coins 10, 20, or even 50 per cent., but there was still something left. Paper enables a Government (if it be foolish or frantic enough) to debase the currency to the level of utter worthlessness.

Inflation with cheques.

The gold standard once abandoned, inflation of the currency takes place not only in the form of notes, but in another, not so plainly apparent. In British communities in particular there is an extensive paper currency in the form of cheques. A banker, for reasons which he considers to be good, grants a customer credit. A sum is entered in the customer's bank account, and he can then draw cheques upon it. These he exchanges for valuable goods and services. Before the war, bankers were deterred from exercising this power too freely by the fact that the cheques were payable in gold, and resulted, after a time, in a drain upon the gold resources of the Bank. If many Banks were over-issuing credit at the same time, there was a consequent drain upon the gold reserves of the Bank of England. The Bank of England then raised its rates for loans, and so discouraged further borrowing.

It is to be noted how inflation, once started, tends to continue. Currency being cheap, prices and values are correspondingly high. A merchant wanting an advance, can produce as security goods or property valued at the enhanced prices. He will probably expect his banker to lend him the usual proportion, but based on those inflated values. If he succeeds, the very credit granted to him by the Bank will bring more paper currency into existence, in the form of cheques, and, as the cheques are no longer payable in gold, an automatic tendency to greater and greater inflation is set up. This can only be held in check when the bankers have the foresight, caution and courage to impose severe limits on the granting of credit.

It is not by the multiplication of the medium of exchange that a nation gets rich, but by the multiplication of the things which it can offer for exchange. Inflation of the currency throws an unfair burden on all persons with fixed incomes. The manufacturer, the merchant, and the workmen can and do protect themselves, but the elderly annuitant or pensioner and the man with a fixed salary is grievously injured.

Notes.

When a Bank note (like that of the Bank of England) is exchangeable for gold on demand, there is no doubt as to its value. It

is currency in a compact form useful in many circumstances. When, however, a Government issues an inconvertible note, what actually is it worth? There is no undertaking to exchange it now or at a future date, for a definite quantity of any specific thing. How then can anyone assess how much of anything it is safe to give in exchange for it? A note is issued under a name taken from the former metallic currency. Surely the use of the name should imply a confident hope, if not an undertaking, that some day it will be exchangeable for that coin.

If there should be no intention to exchange it for the coin, now, or at some future date, then it is nothing short of mendacity to call a note a pound, a franc, a mark, a rouble, or any other name which denotes some object of known and undoubted value.

If there had been no metallic currency what names could be used for these intrinsically worthless instruments? Mill suggested a measurement of values in terms of a day's work. How much, however, is that worth in food or clothing? A day's work of a carpenter might be worth a coat, but a day's work of a surgeon, or an evening's work of a music hall singer, might be worth 500 coats. Unless some tangible thing of fairly constant value be taken for the standard of value, business must be brought to chaos and standstill.

The only criterion of the value of a note is one's belief in the intention, and the ultimate power, of the Government to exchange it some day or another for some thing or another of real value. Faith in the integrity of the Government, or, better still, knowledge of steps which the Government has actually taken with the object of redeeming the note, are the only grounds upon which a note can be accepted as a thing of more value than that of the paper of which it is made.

Even though the first issues of a note may be made with a full intention of keeping something of real value behind them, the temptation to over-issue is great. Governments find that for the time at any rate it is such an easy way to get out of their difficulties. It is fortunate for us that the British and Australian Governments have not yielded to this temptation to any great degree, and are now doing what they can to reduce the volume of the note issues.

Assignats.

A notorious instance of early good intentions being completely nullified by subsequent recklessness is that of the French Assignats of 1792-96. These notes were to be issued to the amount of half the value of the national lands, for which they could be exchanged. The idea was that if the recipient did not want to buy land he could pass the assignat on to someone who did. When introducing these notes Mirabeau said: "There cannot be a greater error than the fear so generally prevalent as to the over-issue of assignats . . . . re-

absorbed progressively in the purchase of the national domains, this paper currency can never become redundant." Alas for the confidence of the politician. It was intended that the total issue should never exceed 1,200 million francs. The first issue, 400,000 francs was a complete success, and circulated at face value. Issues were continued until 3,750 million francs were out, when 100 francs in assignats could be bought for 20 francs in coin. Severe fines were imposed for not taking the notes at their face value. In 1794 the death penalty was imposed, but still the issues increased and the values decreased. By January, 1794, 5,000 million had been issued, and by 1796, 45,500 million francs were out. That was the number of genuine notes issued by the French Government, but the number was also swollen by counterfeits which had been poured into France by foreigners. In 1796 the assignats were exchanged for "mandats," at the rate of one of the new notes for every 30 of the old. These lasted in circultaion for about six months, when they in turn were exchanged for silver coin at one franc for 70 francs in mandats. Thus anyone in France who, in 1792, had received 210 francs for valuable goods and services, found that the money had dwindled in less than four years to one little silver franc.

There have been many such examples in various countries during the last hundred years, and yet all the nations of Europe ventured upon this perilous paper strewn path as soon as the pinch of war expenses began to be felt. The worst example is Russia. Before the war Russia held by far the biggest reserve of gold coin in the world. By now, however, so many different authorities have issued paper roubles, and on such a scale of prodigality, that the notes have ceased to have any value at all.

Rates of Exchange.

The extent of the inflation of any currency can best be measured by the amount of it that has to be paid for in exchange for the currency of a gold-using country.

The present depreciation of the paper pound sterling is assessible by the American exchange rates, the United States being one of the few important countries which at the present time has a real gold currency. As long as the United States is in that position and Great Britain is not, New York has a chance of wresting away from London that financial lead which London in its turn took from Hamburg and Amsterdam a hundred years ago. On the basis of the gold content of a sovereign and a dollar, 4.86 dollars are equal to a pound. This rate is known as the Mint par, because it is based on the intrinsic value of the two coins as they leave the mints in new and full weight condition. The number of dollars which the paper pound sterling exchanged for

from 1915 to 1918 averaged 4.77. After that it fell considerably. The trade boom in England in 1920, and the consequent further inflation of the currency (particularly of the cheque currency) brought about a more serious fall. The lowest price, 3.28 dollars, was reached on 6th February, 1920. Recently there has been a satisfactory recovery, and the rate was quoted on 12th April last at 4.41 dollars.

The following table gives the exchange rates in London of the currencies of eight important countries in 1914, and from 1919 to 1922.

Rates of Exchange.

—		At Mint par.	1914. 11th April.	1919. 12th April.	1920. 10th April.	1921. 14th April.	1922. 15th April.
Paris ...	£1 =	25·22 francs	25·16	27·90	55·00	55·00	47·80
Berlin ...	,,	20·43 marks	20·45	233	233	242	1,305
Vienna ...	,,	24·02 krone	24·02	800	835	1,475	33,000
Warsaw ...	,,	paper only	...	637	670	3,200	16,500
Amsterdam ...	,,	12·11 florins	12·07	11·45	11·52	11·29	11·64
Brussels ...	,,	25·22 francs	25·29	29·30	29·20	53·05	51·67
Stockholm ...	,,	18·16 kroner	...	17·46	17·46	16·35	16·95
New York ...	,,	4·86 dollars	4·84	4·65	3·99	3·91	4·41

The effect of the issue of inconvertible notes on a large scale is clearly seen. People in Germany, Austria, and Poland are of course managing to live and trade somehow, but the difficulties due to everchanging prices must be great. Those with goods to sell must at times seem to make immense profits, until the continued depreciation of the currency robs the money they have received of much of its supposed value. How some persons must have suffered can be gauged by looking at the present value of amounts accumulated in the days of the old metallic currency. A man in Vienna, for instance, who had saved 2,000 krone (about £83) a year for twenty years, and paid it into a bank account, would have had 40,000 krone (or about £1,660) to his credit. The purchasing power of that large sum is now equal to that of 29 only of the metallic krone which he saved. After laboriously saving £1,660 in twenty years, all that he can now put in his pocket is a mass of paper money equal in purchasing power to about twenty-four shillings. Austrian notes

are of so little value that I recently heard of a book which was bound in 10-heller notes, because they provided cheaper paper of the quality wanted than could be got in any other way.

The plight of Russia is worse. No rates are regularly quoted in the London market, but when prices are given they are such as to show that the paper rouble is quite worthless. In the *West Australian* of the 27th May the following cable message from London was published:—

> London, May 27.
>
> The first Soviet Russian steamer, "Karl Marx," reached Hull to-day with a cargo of timber. The vessel was decorated and displayed many pictures of M. Lenin, M. Trotsky, and other Communist leaders. The ship's doctor was wearing an ill-fitting suit, which cost about 12,000,000 roubles. His salary is about 60,000,000 roubles a month, that amount being equivalent to about £3.

According to this information roubles are worth 1s. a million, instead of 2s. 1½d. each.

Stabilising the Exchanges.

There has of late been so much variation in foreign exchange rates, and so much resultant difficulty in trading, that many persons have been seeking for some means by which the rates of exchange could be made more stable. The rates, however, do not govern the conditions of international trade and currency, they merely record what they are. Varying rates are but a symptom of disease, not the disease itself. They changed little before the war, and will again be stable whenever similar conditions of settled trade and tangible currency are re-established. One suggestion has been to take a certain average index figure of prices as normal, and then to alter the amount of gold in a sovereign, whenever the price index goes up or down with the object of ensuring that a pound would always buy about the same amount of things. This would mean that the inevitable fluctuations would be transferred from the amounts of the articles bought to the amount of the article offered in exchange for them. But if I can buy an article for a little pound on one day, and then have to give a big pound for it on another day, the price has gone up, however much I try to delude myself to the contrary. It would not water our stock or nourish our plants, if, whenever there was a drought, we were to pass a law ordering every gallon of water to be called a thousand gallons. In the same way it is difficult to see what benefit could come by calling two pounds one pound, and then saying: Behold, the price has not gone up.

The prices on which index numbers are now calculated are reckoned in a standard as precise and definite as the standards of length

or volume, and with prices so measured the index figures give reliable data for comparing one period with another. With different standards of value every three months (that is one proposal) index numbers and all other records of prices would become meaningless. It is expansion of international trade on the one hand, with currencies of some real and stable value on the other hand, that would effect the stabilising of the exchanges, and make trading far less risky than it is.

Inflation and Gold Mining.

The fall in the buying power of the paper pound sterling has had a disastrous effect on the gold-mining industry of Australia. Stores and services have risen in price, but gold, being still nominally the standard of value, cannot be disposed of (*in Australia*) for more than before. While the Government has been manufacturing paper pounds at very little cost, the mines have been producing the raw material for gold pounds at an ever-increasing cost. If used for currency in Australia the gold pound must circulate as if it were the same as the paper pound. Had there been a great mining boom and an inflation of the currency, due to the over-issue of coin, the consequent rise in prices would have had an automatic and salutary effect in checking further expansion of the industry. What has actually happened, however, is that the industry has been retarded just at a time when more gold production would have been of great value. To save the gold mines from extinction, the Commonwealth Government has permitted a Gold Producers' Association to be formed. The function of this body is to sell gold in the open market abroad for whatever it will fetch, and to divide the profit thus gained among the different mining companies. By this means a number of mines have been able to keep going, although the output in Western Australia dropped from 1,314,043 ounces fine in 1913 to 553,731 ounces fine in 1921, a fall of 58 per cent. The profit obtained by these sales abroad is less than it was a year ago. This is a healthy sign for Australia as a whole, indicating as it does, an approach to the time when the paper pound will buy a pound's worth of gold. Until, however, prices and wages fall in response to the greater buying power of the currency, this improvement will but add to the difficulty of mining without loss. The gold-mining industry is peculiarly unfortunate. In the early years of currency inflation and rising prices no arrangements existed by which it could be saved from loss. Now that the buying power of the currency is not so far removed from that of gold, the profits (in terms of the paper currency) are diminishing, while costs are keeping up.

Price of Gold in Paper Currency.

To justify its name the paper pound should buy 113 grains of pure gold. If it does not do this it is a depreciated form of cur-

rency, and the amount of its depreciation can be measured by the weight of gold that it does buy. The highest price in the paper pound sterling for which gold has been sold was £6 7s. 4d. per ounce fine on 5th February, 1920. From that date to November, 1921, there were many fluctuations, but the average was about £5 10s. 7d. On the 27th April last it was £4 13s.

When the (paper) price of fine gold per ounce is:			The paper pound buys:	Percentage less than it ought to buy:
£	s.	d.	grains of pure gold.	%
6	7	4	75	33
5	10	7	87	24
4	13	0	103	9
4	4	11½	113	(the full value)

In the two years and two months from February, 1920, to April, 1922, the Australian paper pound rose in value by 24 per cent.—an important and satisfactory advance. If this rate can be maintained the level of the gold standard will be reached in less than a year's time. Even if this should be attained, it does not follow that there will be a return to the use of gold for retail transactions, or a return to pre-war prices. If during the 26 months prices have not fallen by a similar amount (and they do appear to have done so) then gold must have depreciated in value, and gold prices themselves are higher than they were. That this is the case is indicated by high prices in the United States, where the gold standard is unimpaired. The use of gold coin for retail trade is a matter of convenience, and to some degree of health (notes being splendid germ carriers). From the currency point of view it does not matter in the least whether coin is so used or not, provided that the notes can always be exchanged for the coin *on demand.* A large store of solid wealth in the pockets of the people, however, proved to be very useful when the war broke out, and might, if re-instated, be a great help to the Government in some future similar emergency.

British and Australian Notes.

Tables are shown below giving the issues of British Treasury notes and Australian Commonwealth notes. It will be seen that whereas the Commonwealth Government holds gold to the value of 43 per cent. of the total note issue, the gold backing of the British notes has as yet reached only 16 per cent. of their total issue. Out of 319 millions in notes 266 millions are issued against Government securities. This is better than no security at all. Nevertheless the issue by the same authority of an implied promise to pay (the notes) on the security of a former definite promise to pay (bonds,

etc.) cannot be considered a satisfactory arrangement. The table shows that the British Government has recently reduced the number of notes, and thus improved the status of those that are left. It is to be hoped that peace and reviving trade will enable it to continue steadfastly on that road until the point is reached at which the paper pound will exchange for 113 grains of pure gold.

A table showing the issue of Bank of England notes is also given. These have such a large backing of gold (87 per cent.) that they are usually looked upon as "as good as gold." It is to be noticed that the Government holds some of them as security for the Treasury notes.

Inflation of the currency by notes is best corrected by the opposite process—the destruction of notes, rather than by piling up a big store of gold to support them. In the early years of the 19th century, owing to the Napoleonic wars, Great Britain had then, as now, a paper pound, and the Governors of the Bank of England were so impressed with the necesssity of holding gold to support the notes that in 1815 they bought gold at 80s. an ounce standard for that purpose. That is to say that they paid £1 0s. 6d. (in notes) for £1 in gold. They could have bought the notes and burnt them at less expense. During the suspension of specie payments from 1797 to 1815 the written promise to pay for notes in gold was kept on them, presumably in the hope that the words would some day come true again. They did so after the lapse of 19 years. The same course is being followed in the case of the Commonwealth notes. The promise is still on them. We may reasonably hope that the words will be true in the case of our notes in much less than 19 years.

British Treasury Notes.

(In millions of pounds.)

—	Amount issued.	Gold coin.	Silver coin.	Bank of England notes.	Percentage of coin and Bank notes to Treasury notes.	Govt. Securities.	In Bank of England.
In April—							
1915 ...	41	27	...	...	66	8	5
1916 ...	111	28	...	...	25	76	7
1917 ...	152	28	...	...	19	115	9
1918 ...	242	28	...	...	12	209	5
1919 ...	352	28	...	...	8	318	5
1920 ...	356	28	...	6	9	321	1
1921 ...	358	28	...	19	13	311	...
1922 ...	319	28	5	19	16	266	...

AUSTRALIAN (COMMONWEALTH) NOTES.

		£	
27th March, 1922—Held by Banks	... ...	31	millions
In active circulation	... ...	23	millions
Total	... ...	54	millions
Gold held	... ...	23	millions
Percentage of gold to total	... ...	43	per cent.
" " " notes in circulation	...	102	per cent.

BANK OF ENGLAND NOTES.

(In millions of pounds).

——	Issues.	Gold coin held.	Percentage of gold coin to notes.
In April—1914	53	35	66
1915	72	54	75
1916	75	57	76
1917	71	53	75
1918	78	60	77
1919	102	84	82
1920	130	112	85
1921	145	126	87
1922	146	127	87

During the period of currency inflation and rising prices the consumer everywhere suffered, and much was heard about the iniquities of the "Profiteer." Now that deflation has begun, it is the consumer who will benefit, and the merchant and the manufacturer lose. The position is complicated by the fact that in the meantime prices of materials and rates of pay have risen. Unless these prices and rates can again be lowered, some may find it impossible to carry on. There is, however, little likelihood of prices and wages returning to pre-war levels. Prices arose immensely during the Napoleonic wars, and never again fell to the 18th century level. The effect of war on prices has usually been an all-round permanent rise.

The depreciation of the paper pound (as shown by the sales of the Gold Producers' Association, and by the American exchange rates) is now only about nine per cent. Prices throughout the world are high, when reckoned on the old gold basis, and it needs only a small fall in (paper) prices to bring them to the gold price level. The difficulties, therefore, of the manufacturer and the merchant are not likely to be so great as many of them seem to fear. The unfortunate individual with the fixed income, however, will be wise not to look forward to any great amelioration of his lot. If he is

philosophical and altruistic, he may extract comfort by reflecting on the fact that continued high prices will make it much easier for his nation as a whole to pay off its debts.

The ideal is to have prices and values stable over long periods. It does not matter so much whether the prices are thought to be high or low, the important thing is that they should not alter, or, if they must alter, then only at a very slow rate, so that adjustments can be made without suddenly saddling one section of the community with unexpected gains, and another with unexpected and possibly crushing losses.

The United States, Mexico and Japan are the only important countries which still have a gold standard and gold coins in use. As far as the British Empire is concerned there is a steady return to the position when a note will buy as much a sovereign, that is to say, to a currency really based on gold.

The most serious problem of the future, the solution of which is at present in complete doubt, is, by what means and when, will the countries of Europe put their currencies in order. Possibly some adaption of the "gold exchange system" will present a way out of the existing chaos. Under this system gold would always be bought at a fixed price in the currency of the country concerned. That would give the notes a definite constant value in foreign countries. It would not so much matter, for instance, whether the pound bought 100 paper marks or 1,000 paper marks, so long as it always bought the same number.

Stability of trade, and consequent prosperity, depend finally on the productive power of the people of all the trading nations. Currency and financial policy are designed (or should be designed) to help production and distribution. If the crops, minerals and manufactures be not produced, the most perfect currency system is of no avail.

Trade may be likened to a machine; currency to the lubricating oil without which it cannot be used. In order to re-establish prosperity more machines (trade) are wanted, and just enough oil (currency) to keep them moving freely.

PEDIGREE SELECTION OF SEED AT THE CHAPMAN AND MERREDIN EXPERIMENT FARMS.

By Geo. L. Sutton.

(*Read 12th October*, 1921.)

"I've seen the largest seed tho' viewed with care
Degenerate, unless the industrious hand did yearly cull the largest."
—*Translation from Virgil's Georgics.*

"Pedigree" or "Pure Line" selection is that system of selection under which the choice is made, not solely because of the attractive appearance of the plant, but because of its ability to transmit its good qualities to the progeny. Such a system requires, and the method of selection ensures, that the qualities sought after shall be hereditary. For this purpose a record of ancestry is essential, hence the use of the term "pedigree."

It was by use of such a system that the late Wm. J. Farrer produced and fixed his productions. This system of selection is probably identical with the "single plant" selection of the Vilmorins, and which became known on the Continent of Europe about the middle of last century as the "Vilmorin" method. It was shown by Vilmorin to be the quickest method of obtaining a pure and uniform strain.

Owing largely to the success which has attended the re-discovery of this method at Svalof, Sweden, in 1891, and its general adoption by the Experiment Stations in Denmark, the system of "pure line" breeding or "pedigree" selection is regarded as the soundest method for producting seed of uniform type of the highest quality.

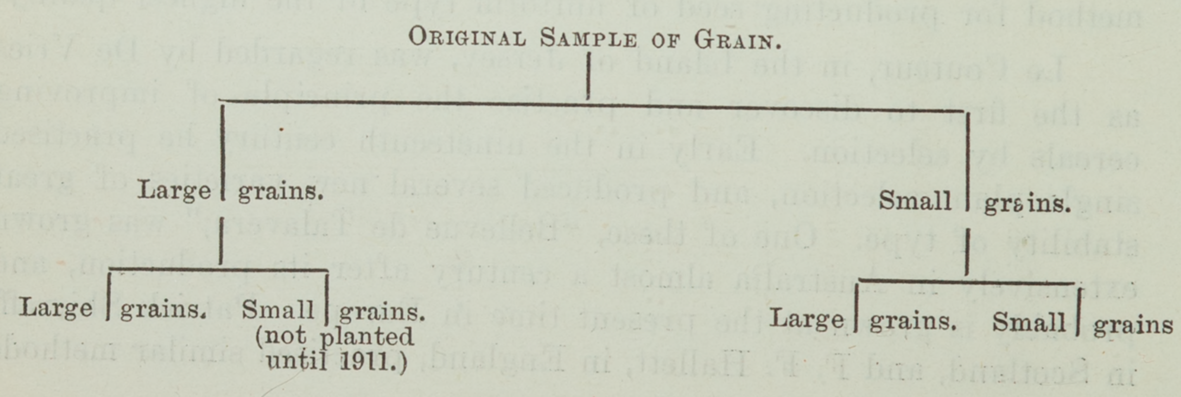
Le Couteur, in the Island of Jersey, was regarded by De Vries as the first to discover and practise the principle of improving cereals by selection. Early in the nineteenth century he practised single plant selection, and produced several new varieties of great stability of type. One of these, "Bellevue de Talavera," was grown extensively in Australia almost a century after its production, and probably is grown at the present time in Europe. Patrick Shirreff, in Scotland, and F. F. Hallett, in England, practised similar methods

about the middle of the same century. The merits of the "single plant" system seem to have been well recognised even at this date, for a recent writer, referring to this period, states: "The method of building up a new variety of cereals from the produce of a single plant seems to have been so well known as to call for no special comment."

Hallett adopted the single ear, and even a selected grain from that ear, rather than a single plant as the basis of his selection, and was apparently the first to apply the term "pedigree" to the seed produced by him. Hallett's aim was to choose the one ear which produced, not only the largest number of kernels, but the best formed ones; an essential feature of his method was repeated selection, and it was remarkable for the minute care and immense amount of work involved.

The selection of the best grains did produce high-yielding plants, but Hallett was not apparently aware that the plump grain of their progeny would not produce higher yielding plants than the plum grain of the progeny of the smaller grain from the same plant.

That this is so is shown by the results of an experiment carried out at the Wagga Experiment Warm, N.S.W., during the years 1902-1911 in continuation of one commenced by Dr. N. A. Cobb in 1895. This experiment was undertaken with the object of determining whether the practice of continually selecting and sowing large grains would result in an improvement in the constitutional character of the grain so as to make the strain more prolific. To test this point, a sample of seed grains was taken and divided by means of a sieve into large and small grains, so that the differences were extreme. These were planted, and the product of these was again similarly divided for the purposes of the experiment. The large grains from the previous generation of large grains were called the large grains from the large-grain row. The product of the small grain was divided, respectively, by a screen into large and small grains. As these grains came from the row planted with small grains, they were respectively known as the *large* and *small* grains from the *small-grain* row, and were used to plant sections (2) and (3). This scheme is shown graphically as follows:—



To eliminate any differences due to peculiar varietal characteristics three varieties were used, and planted under the same conditions; the results obtained are as hereunder:—

Yields of various grades of Seed Wheat at the Wagga Farm, New South Wales.

Year.	Largest grain from "large grain row."				Smallest grain from "large grain row."				Largest grain from "small grain row."				Smallest grain from "small grain row."			
	Allora Spring.	Hudson's E.P. Straw.	White Velvet.	Total.	Allora Spring.	Hudson's E.P. Straw.	White Velvet.	Total.	Allora Spring.	Hudson's E.P. Straw.	White Velvet.	Total.	Allora Spring.	Hudson's E.P. Straw.	White Velvet.	Total.
	oz.	oz.	oz.	lb. oz.	oz.	oz.	oz.	lb. oz.	oz.	oz.	oz.	lb. oz.	oz.	oz.	oz.	lb. oz.
1902 ...	17½	15½	19	3 4	...	...	...	...	16¾	16¾	15	3 0½	6	6	6	1 2
1903 ...	29	25	34	5 8	...	...	...	...	29	30	32½	5 11½	18½	21	13½	3 5
1904 ...	32	30½	28½	5 11	...	...	...	...	31½	34	30½	6 0	15½	18	18	3 3½
1905 ...	29	28	37¾	5 14¾	...	...	...	...	23	30¾	35	5 8¾	15¾	19¾	21½	3 9
1906 ...	33	21½	25	4 15½	...	...	...	...	35½	29½	31¼	6 0¼	18¾	13	18¼	3 2
1907 ...	14	24	15¾	3 5¾	...	...	...	...	19½	20¼	16¾	3 8½	9	11½	9¾	1 14¼
1908 ...	35½	32¾	33	6 5¼	...	...	...	...	33¾	30¾	35½	6 4	22	18¾	17¼	3 10
1909 ...	22¼	32	32½	5 7	...	...	...	...	28¼	32¾	30¾	5 11¾	11	14¾	8	2 1¾
1910 ...	78	61½	54¼	2 2¾	36½	27	29	5 13¼	79	69	58½	12 14½	25¼	27½	16	4 4¾
1911 ...	18¾	23¾	24½	4 3	7	8¾	12¾	1 12½	20¾	20½	23¾	4 1	5½	7¾	10¼	1 7½
Averages	...	...	...	4 10	...	...	...	...	...	...	...	5 14	...	...	...	2 12

If improvement were possible by this method of selection, it is obvious that gradually the yield of seed continuously selected from the large grains would be greater than the yield obtained by continuously using the small seeds.

The results show that this is not so and that the mechanical selection does not effect an improvement in the constitutional character of the grain. If it were otherwise, it would be found in 1909 that the seed which was the progeny of continuously selected best—*i.e.,* large grain for eight years would produce more prolific plants than similarly sized seed, which was the grain obtained as the result of using continuously the worst (smallest) grain for eight years. The average and final results show that this is not the case. The yields from plump grain from either source are, approximately, the same, though slightly in favour of the large grain, which was the progeny of previously selected small grain.

From these results, it appears evident that the marked benefit due to the selection of large grains for seed, reaches its maximum at once, as the immediate result of such selection. The increased yield due to the planting of large grains is not due to any superior constitutional character of the grain, but rather because the larger grains give the young plant a better and more vigorous start in life, a factor which must be considered of very great importance, and of which advantage should be taken.

There is little doubt that selection in some form or other has been practised right down through the ages of agricultural development. Darwin has stated that the improvement of rice by selection was practised in China thousands of years ago, and Virgil refers to the intentional saving of the best grains for a succeeding sowing. It is probable that the earliest system of selection adopted was that under which the largest grains were chosen and planted, and this followed by that under which ears were selected each year in the field in order to provide seed for a nursery plot in which to raise seed for a succeeding main crop. Some farmers still practice this method. An advanced plan is that of making a selection of ears each year from the nursery or elite plot. This system is known as Mass Selection, and is still practised, though to a decreasing extent. Mass selection was the method in general use during the latter half of the past century, and was in vogue at Svalof until 1892, when the method of "single plant" selection was rediscovered. By its use Rimpau, in Germany, produced the superior strain of Rye known as "Schlanstedt." Until the time it was superseded in favour of "single plant" selection, the Mass Selection method was used by Louis de Vilmorin in connection with the improvement of Sugar Beet, and it resulted in a large increase in the amount of sugar produced per acre . . . . Mass selection certainly has advantages, but as was found at Svalof, it has the disadvantage that it does not make for uniformity, and as

all the benefits to be desired from Mass selection, together with the added one of uniformity, can be achieved equally as well, more quickly and with more certainty by "pedigree" or "single plant" selection, the latter method is becoming more and more generally adopted.

The practice of growing pedigree selected seed at the Chapman and Merredin Farms was commenced in 1912, the season following the arrival of the writer in this State.

The object of the selection work undertaken was:—

(1) To secure purity of type.

(2) To obtain high yielding strains or lines, and

(3) To maintain the prolificacy of the varieties at their highest possible level.

The first object is achieved as the result of choosing a single plant as the "Unit of Selection." This was the unit previously adopted in New South Wales, and the natural corollary of the methods adopted under the guidance of the late Wm. Farrer for the production of new varieties by cross-breeding.

The adoption of such a unit ensures a sound foundation for the attainment of the first object, because the selection of a single plant as the starting point undoubtedly supplies a source free from admixture, being, as it is, the product of a single seed. The second objective is secured by selecting in the first place a number of plants —30 or more, of attractive appearance, and of good yielding quality. If the original test consists of more than thirty plants, the number is eventually reduced to thirty by trial. These plants are then subjected to further selective tests to demonstrate their ability to transmit their most desirable characteristics in their progeny. This is determined by ascertaining, by trial in the field, the average productivity of a definite number of plants, usually 100, and the progeny of each plant, and comparing the results with each other. This method of comparison is a modification of the "Centegener" method of W. M. Hays, of Minnesota, adapted to suit our conditions.

The plants grown for trial in these rows are called "Lines." A "Line" is defined as consisting of a number of plants grown from the seed produced by a single parent plant. The ground on which pure lines are grown is treated in the same way and under a similar rotation to that adopted for the main crops of the farm. No attempt is made to give them specially good environmental conditions. The desire is to have the tests made under rather more severe conditions than obtain under ordinary farm conditions.

As the result of a second selection, half the plants are eliminated, and a third test undertaken. In this test each two representatives or lines of the original parent line are grown, these two lines being known as a "Family." A "Family" being defined as a number of

pure lines, each the progeny of the same parent, *i.e.*, of a plant belonging to the same pure line. The third selection consists of choosing the best six "families" from the fifteen used in the second later test. The fourth selection in which five lines belonging to each family are tried, reduces the number of families to three, and the fifth and final selection to one. This is the starting point of the pure "strain" or "race" aimed at. A strain is defined as a collection of "families" produced by seed obtained from the same source, and when each family constituting the strain can be traced directly to a common ancestral plant, the strain is said to be "pure" selected or "pedigree."

To achieve the third objective and to maintain the prolificacy of the strain at the highest level, the same system of selection is continued so as to choose each year the most prolific family. The three most prolific lines in that family are chosen to provide the families of the next generation. The balance of the seed is used to plant a "nursery" or "elite" plot, which in its turn provides from 30 to 60 rows and produces from 1 to 2 bushels. The seed from the "nursery" or "elite" plot is known as "selected bulk" seed, usually marked "bulk." This grain obtained from the "elite" plot, sown thinly with an ordinary farm seed drill, will plant 5 acres or more; the area so planted is called a "stud" plot, and the seed therefrom is known as "stud" seed. The produce of the "stud" plot—80 to 100 bushels—is utilised for planting the main crops of the farm, the produce of which, when graded, is the "pedigree" seed sold to farmers.

It may be thought that such a method would require a long time to grow enough seed for commercial purposes, but a little calculation will show that this is not the case. After the initial selections necessary in connection with a mixed strain have been made and the system of selection contracted to three related families, it is found that only four years elapse between the original selection and the production of seed on a commercial scale. This is shown in the accompanying diagram which has been arranged by my assistant, Mr. Vanzetti, to show, in a graphical form, the system in vogue at the Experiment Farms at Chapman and Merredin.

To avoid errors, and also to assist in detecting them when they occur, very definite instructions are laid down with regard to the method of carrying out the various operations. These details have been decided as the result of experience gained in past years, and are to be observed as rigidly and seriously as a sacred ritual.

So that an exact record may be secured of the plants sown and the tests made, the rows must be laid out systematically and in accordance with a well designed plan.

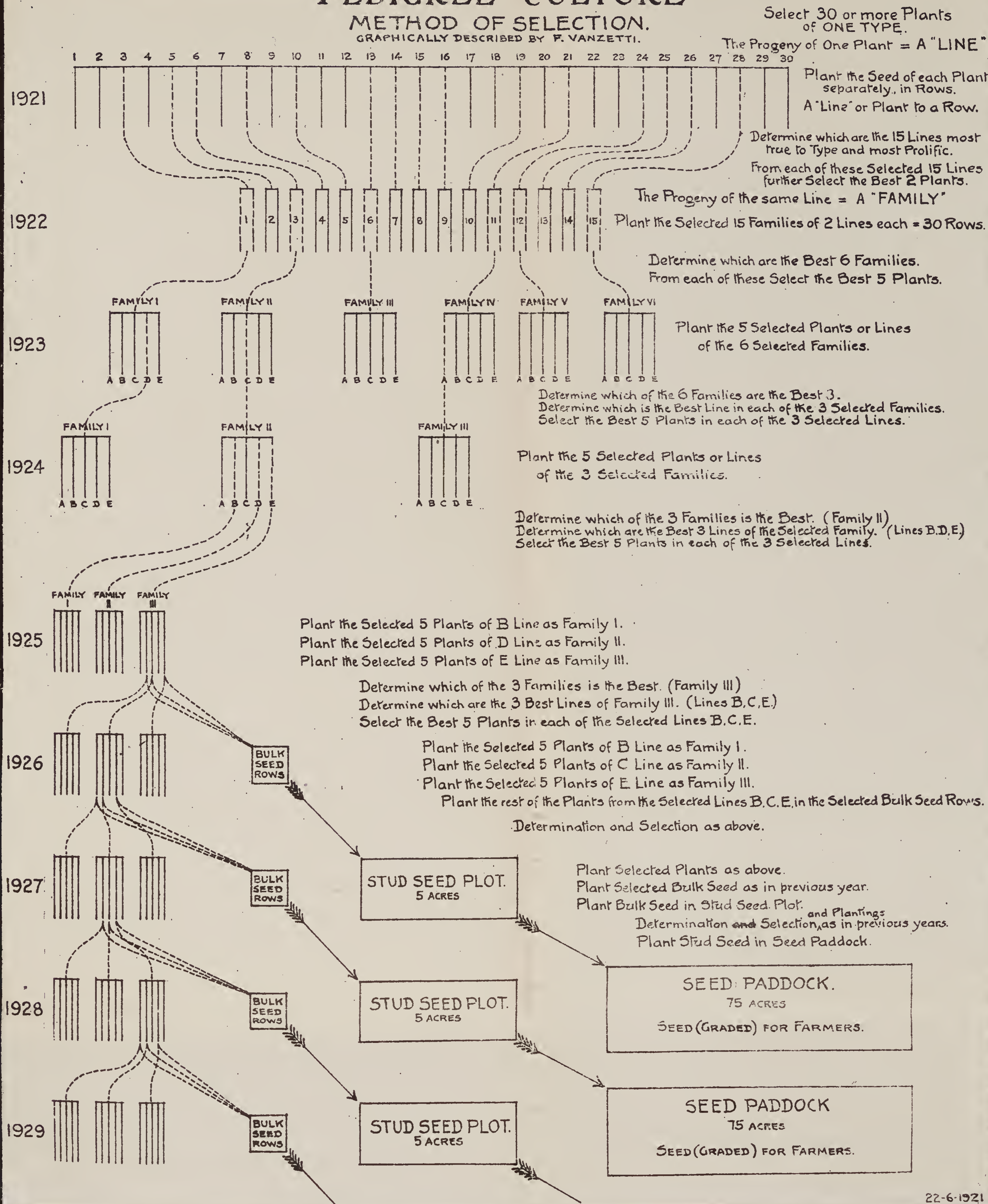
The area on which this pure line breeding is carried out is first divided into sections, 1 chain long with divisions or pathways be-

MERREDIN AND CHAPMAN EXPERIMENT FARMS.

·PEDIGREE CULTURE·

METHOD OF SELECTION.

GRAPHICALLY DESCRIBED BY F. VANZETTI.



tween them at the ends, 3 links wide. Each section is then divided into rows 2¼ links apart. The rows are numbered so that the one nearest the farm buildings is No. 1. The sections are distinguished by letters, the small letters of the arabic rotation, a, b, c, etc., being used for this purpose on the seed packet.

Before commencing to plant the seeds, the different rows and sections are measured off on the ground just as a draughtsman would mark them on a plan.

To facilitate locating the different rows, every tenth row in each section is marked with a labelled peg or plate. This plate has the sectional letter (in this case a capital letter) and the number, without the final cypher, on it. Thus the peg or plate on the 80th row in section b would be marked $\frac{B}{8}$. The families are distinguished one from the other by the Roman numerals I, II, III, in order of merit, commencing with one. The selected plants are distinguished by the capital letteers A, B, C, D, E, the choicest being A. When the system is established, the seed to be planted consists of five "lines" of three families for the purposes of the best comparison.

Under the methods adopted at the Chapman and Merredin Farms, the "lines" are sown in parallel rows instead of in plots planted draught-board fashion as under the Minnesota plan. Each row is one chain long, so that the one hundred plants constituting a line are each one link (8 inches) apart, with the first and last seeds half a link from the boundary lines of the section. This gives ample room for plant development and affords facilities for easy observation of the individual plants. In order to ensure that the plants be spaced uniformally at link intervals, the early practice was to place a chain measure in the shallow furrow opened up for the reception of the seed and place a seed at each link mark; later a toothed wheel was designed which made indentations 1¼ inches deep at intervals of one link apart, but now those planting the seed have become so expert that they can drop the seed with great accuracy without mechanical aids.

In order to afford easy access to the plants for examination the rows are 2¼ links (18 inches) apart. They were originally 2 links apart (16 inches), but the greater width has been adopted so as to permit the ground between the rows to be cultivated by horse-drawn implements. This inter-cultivation during the growth of the plants keeps the weeds down and prevents their interfering more with the growth of some plants than with others. This is important in view of the necessity for seeing that the conditions for comparison are as uniform as it is possible to make them; and in this connection, so as to afford the best conditions for comparison, all the lines of one family are not planted adjacent to each other, but similar lines of the different families in their order of merit are planted in adjacent

rows: for example, with the five lines A, B, C, D, and E of three families, I, II, III, the planting would be as follows:—

Line A,	Family I,	would be in, say, row	101 a
„ A,	„ II,	„ „ „	102 a
„ A,	„ III,	„ „ „	103 a
„ B,	„ I,	„ „ „	104 a
„ B,	„ II,	„ „ „	105 a
„ B,	„ III,	„ „ „	106 a
„ C,	„ I,	„ „ „	107 a

and so on.

The plants are examined during their growth, especially as they approach maturity, to determine their characteristics and their peculiarities. At the same time diseased or stray "rogue" plants which have found their way into the row can be removed. This work is facilitated by the planting at the uniform distance of 8 inches apart. Plants observed with specially striking characteristics are also noted and, if desirable, marked in a distinctive way.

At harvest time the object in view is to obtain at least five selected plants from each of the best three lines of the most desirable family. The first step is to determine the most desirable family; sometimes it is possible to do this by observation in the field, but if this cannot be done the final determination is only made as the result of weighing the grain thrashed from each family. In the former case the best eight plants, to allow for a subsequent partial rejection, are selected from the three most desirable or from all the lines of the chosen family. In the latter case the best eight plants are selected from the most desirable lines of all the families.

The chosen individual plants are harvested by placing the hand around all the steams at the ground and drawing them together and holding them whilst the ears are cut off with about 12 inches of the stem attached. The ears are then arranged neatly together, and the stems tied securely just beneath the ears. The stems are then cut to a uniform length of about 9 inches.

The individual plants harvested from the same "line" are tied together, and a label attached which gives the name, the pedigree of the plants, including the registered number of the variety, the date harvested, the row in which the plants were grown, and the letters A, B, etc., indicationg the specially selected plant which was the parent of the line. This plant is always marked with the plus sign -|- to indicate that it was selected.

To ensure uniformity in connection with labels and tickets the details relating to the seed harvested are placed in a definite position on the packet or labels. The name of the variety and its source are placed in the centre of the ticket or label. The row in which

the plants were grown is placed at the right-hand top corner, and the date harvested in the right-hand bottom corner. A typical label or ticket is as follows:—

138a
GLUYAS EARLY. P. 1348. + plant A.
11-11-19.

The principle underlying the system of pedigree selection is the conception that just as varieties differ in regard to their characteristics so do the individual members of the varieties vary in a similar, albeit minor degree. It follows from this that strains of greater merit than the average of the variety can be obtained within the variety. This conception is in tune with the Testing of Dairy Herds and the Single Pen testing for egg production. The general realisation of this conception by agriculturists will mark a distinct stage in agricultural progress just as it is believed that the separation of species into varieties marked a progressive step in the past.

In the production of "pedigree seed" we have a factor of considerable commercial importance because of its bearing upon the increased productivity of farm crops without disproportionately increasing the cost of production. The superiority in prolificacy which is the foremost advantage of pedigree seed has been so proved in Australia and elsewhere that it may be a reasonable expectation to see the everage yield of our main cereal crop raised 10 to 15 per cent., solely by the general use of "pedigree" seed, not solely as seed for planting the main crops but used systematically in a definite percentage in order to produce the seed for such crops.

CONTRIBUTIONS TO THE FAUNA OF WESTERN AUSTRALIA.

No. 1.

By L. Glauert, W.A. Museum, Perth, by permission of the Trustees.

(*Read December* 13, 1921.)

Petrogale rothschildi. Thomas.

In 1901 when collecting in North Western Australia on behalf of the Hon. Walter Rothschild and this Museum, Mr. John T. Tunney obtained one skin of a Rock Wallaby, which proved to be distinct from known species. It was examined by Mr. Oldfield Thomas and named as above.

The Museum has recently received three damaged skins (M527/529) of a Rock Wallaby, shot by Mr. L. Le Souef at Nicol Bay, which, upon examination, prove to belong to this rare and little known species. It is unfortunate that the skulls were not preserved, as the cranial features of the species are, as yet, unknown. It is hoped that it will be possible to obtain further specimens in the near future, so that an accurate diagnosis may be prepared.

The species is readily distinguished from *P. lateralis,* a form ranging from Kimberley to the South Coast, by its shorter and coarser fur, its dark head and ears and the absence or indistinct development of the nuchal stripe and flank markings.

Dasycercus cristicauda (Krefft.)

In 1907 the Museum received a skin of a species of Phascogale from Mr. A. W. Canning, who had recently returned to Perth after surveying a stock route from Wiluna to Kimberley. Owing to its imperfect state and the lack of other material, the identity of the animal could not be established with certainty, and the matter was therefore, deferred until a more favourable opportunity.

Mr. E. Le G. Troughton, of the Australian Museum, Sydney, who has recently been collecting in South Australia, obtained a fine series of *Dasycercus cristicauda* on the Nullarbor Plains, with which

the Canning skin has been compared. It is now possible to make a definite record of the presence of this Central Australian species in Western Australia. The skin was obtained 500 miles North of Wiluna, which would be somewhere in the vicinity of Mount Romilly, say, 20 degrees 20 minutes S. and 126 degrees E.

Nyctalus noctula (Schreber.)

This Bat, which has been recorded from a vast area, including Europe, Northern Africa, the mainland of Asia, Japan, Java and other islands of the Dutch East Indies, has not up to the present been reported for Australia. In 1899 Mr. J. T. Tunney obtained five specimens near Lawlers, which were submitted to Mr. Oldfield Thomas, of the British Museum. Mr. Thomas states that he can find no point of difference between the specimens from Lawlers and those obtained in Europe.

Halobaena caerulea (Gmelin.)

A specimen of this rare Blue Petrel was found on the beach, North Fremantle, by Mr. B. R. Lucas, on October 12th, 1921, and presented to the Museum. This is an interesting record, as it constitutes the third occasion upon which the bird has been found on the Australian mainland.

Mr. Gregory M. Mathews has a specimen picked up on a beach in Victoria. Mr. Edwin Ashby records a specimen found on the jetty at Port Willunga, in South Australia, on April 29th, 1914, as reported in the South Australian Ornithologist, Vol. I., Part 3, page 15, July, 1914. As I can find no other reference, I conclude that the specimen from North Fremantle, in addition to being the first record for Western Australia, is the third for Australia.

Podiceps cristatus (L.)

A specimen of the Great Crested Grebe was purchased from Mr. Ostle, who shot it on Herdsman's Lake on December 5th 1921. This bird is rarely seen in Western Australia, only three specimens are in the Museum collection and no other Western Australian specimens are known.

Trachynotus botla. Shaw.

The Dart, which is a common food fish in the Eastern States, is not often seen in local fish shops, as its usual range in Western Australian waters appears to be north of Geraldton. The Chief Inspector of Fisheries (Mr. F. Aldrich), recently presented a fine specimen caught off Fremantle.

Thyrsites atun. Euphr.

There is in the Museum collection one specimen of Barracouta, purchased at the Fremantle fish market in 1908, which may be regarded as a definite record of the presence of this fish in Western Australian waters. It is unfortunate that a more definite locality is not available.

Lingula tumidula. Reeve.

This striking Brachiopod, which has previously been recorded from the Philippines and Queensland, is an addition to the Invertebrate Fauna of the State.

The specimen exhibited was obtained near Broome Lighthouse and presented to the Museum by an enthusiastic local Conchologist, Mr. E. H. Bardwell. The species is one of the largest, if not actually the largest living species and is also remarkable for the breadth of the shell features, which readily distinguish it from all known recent Lingulas.

Cilicaea latreillei (Leach.)

In March last, Mr. Stanley, Assistant Engineer at the Henderson Naval Base, submitted for examination a piece of white wood, very much damaged by boring animals. The wood had been submerged at a depth of 42 feet for about 12 months, and during that time had become completely riddled by "ship worms," and an Isopod Crustacean, which I have been able to identify as *Cilicaea latreillei* (Leach), previously recorded from King George Sound. The economic importance of the discovery lies in the fact that this species has not previously been recorded as a wood-destroying Crustacean.

There is no doubt from the nature of the chambers and galleries that the Crustacean was responsible for the cavities in which it was found.

Sphaeroma guoyana (M—Edw.)

This Isopod Crustacean, which is known to bore into soft rock and wood in Eastern Australia and New Zealand, was found in great numbers when I was examining a damaged pile raised from the water in my presence at the North Wharf, Fremantle, on March 8th last.

This constitutes the first record of the presence of this dangerous little Isopod in Western Australia.

As a result of further investigations, it was found to be infesting timber at Crawley, where it was in the unsound keel of a boat belonging to the Sea Scouts' organisation.

NOTES ON THE AUSTRALIAN REPRESENTATIVES OF THE GENUS ACANTHOPLEURA, GUILDING, TOGETHER WITH A DESCRIPTION OF POLYPLACOPHORA IN THE WESTERN AUSTRALIAN MUSEUM.

By Edwin Ashby, F.L.S., M.B.O.U.

Read December 13, 1921.

The writer is indebted to Mr. L. Glauert, of the W.A. Museum, Perth, for the opportunity of examining and describing the specimens dealt with in this paper.

Acanthopleura gemmata (Blainville.)

(*Chiton gemmatus* (Blain), Dict. Sc. Nat. XXXVI., p. 544, 1825, *Chiton spiniger,* Sow. of Pilsbry, Man. Con. Vol. XIV., p. 222, auct.)

In November last year, Mr. Glauert placed some Chitons in my hands for identification, and amongst them were representatives of a large species with a spiculose girdle, but the whole of the exposed portion of the shell was eroded. On disarticulating one of them, it was seen that the portion of the sculpture that had in some measure been preserved corresponded with a shell given me by Mr. J. H. Gatliff, from Port Darwin, where he had himself taken it.

This shell was given me under the name *Acanthopleura spiniger,* Sow. When I showed it to Dr. Pilsbry, in Philadelphia, in 1918, he told me that he considered that it was the shell described by Blainville, as *Chiton gemmata,* in 1825, thus antedating Sowerby's name *spiniger.* I have no doubt as to the correctness of Dr. Pilsbry's determination. Dr. Pilsbry also said that it should be placed under his sub-genus *Amphitomura,* and I marked it accordingly.

On receiving the W. Austr. specimens from Maud's Landing, No. 9326, it became necessary to compare them with the forms occurring in the Northern Territory and Queensland. Dr. John Shirley kindly supplied me with specimens from Dunk Is. in that State.

In the Western Australian shells No. 9326, the insertion plate of the anterior valve is long, numerously slit, thick, the teeth serrated and deeply grooved rather than laminated on the outside. The

colour of the insertion plates is pale greenish blue. The Port Darwin shell is similar in all respects except that the teeth between the slits in both anterior and posterior valves are more laminated and less solid. This may well be accounted for in the fact that it is a half grown shell.

In the Dunk Is. shell the insertion plates of the end valves are not as long, the teeth more laminated, the colour dirty brown and the 8 slits in the tail valve not quite so well defined. As far as the eroded condition of the shell will allow determination, the sculpture of the shell and the girdle spines seem identical with the Port Darwin and Western Australian specimens.

Nevertheless the differences noted above in the insertion plate, especially of the tail valve, suggest that the Dunk Is. specimens may belong to a distinct geographical race. If it be thought wise to distinguish this form with a name, I should suggest that of *Queenslandica.* The wisdom or otherwise of adopting this course must be left for final determination on the examination of more and less eroded material.

The next step to determine was as to whether the Australian shells should be placed under Dr. Pilsbry's sub-genus *Amphitomura* of which *A. bourbonica,* Deshays, is cited by Dr. Pilsbry as the type?

In the valuable collection of Polyplacophora, which Commandant Paul Dupuis has so generously given to me, are two specimens of *Amphitomura bourbonica,* Desh., from Mauritius. These show in the tail valve short, blunt insertion plates with one slit each side, and accord perfectly with Pilsbry's description of that sub-genus.

It is quite certain that the Australian shells with their long insertion plates, multi-fissate in the tail valve, cannot be referred to this sub-genus. I then disarticulated a half grown specimen of *Acantropleura* (*Mesotomura*) *echinata,* Barnes, from Valparaiso, Chile, which is Pilsbry's type for this sub-genus. The insertion plates are very different from the other representatives of the genus *Acanthopleura,* in the anterior valve they are long and thin, very deeply laminated on the outside and very sililar in the tail valve, but in this valve instead of being bent forward, as is the case with the Australian shells, they are bent backwards, as in most species of *Polyplacophora.* There is a modified ventral slit and in the sinus between the sutural laminæ there is a lobe or spade-like process similar to the living representatives of the genus *Loricella,* see my paper "Description of a new species of fossil *Loricella,* etc. (Papers and Proceedings Royal Society, Tasmania, 11th July, 1921). These very distinct characters in the tail valve sure will justify us in giving to Dr. Pilsbry's sub-genus *Mesotomura,* full generic rank.

This will leave three sub-genera under *Acanthopleura: Acanthopleura,* s. str., with multi-fissate tail valve with the insertion plates

long, grooved and bent forward, the sutural laminæ joined across the median line but without any spade-like process in the sinus; *Maugeria,* Gray, 1857, which has short insertion plates but in other respects corresponds very closely with the preceding sub-genus; and the third, *Amphitomura,* Pilsbry, which has been referred to above.

The Australian shells evidently belong to the first-named *Acanthopleura,* s. str., no representatives of the last two having yet been met with in Australia.

Acanthopleura spinger, Sow., Mag. of Nat. Hist. 1840, p. 287, Suppl. pl. XVI., f. 2; P.Z.S. 1841, p. 61; Conch. Illustr. f. 68. Reeve, Conch. Icon., t. 14, f. 75, Pilsbry, Man. Con. l.c.

I have well-preserved specimens in my collection from the west coast of Sumatra sent me by M. Nils Odhner, of Stockholm, which correspond with Sowerby's description and figure, with two exceptions: the radial ribs shown in the drawing of the anterior valve are less in evidence and of a less number; also in the specimen from Sumatra the girdle encroaches at the sutures more than half-way across the valves in a way that is not shown by Sowerby but is clearly depicted in Reeve's figure of a shell from the Philippines. As the locality from which Sowerby's type came is uncertain, I think we may conclude that it was not from Australia for the following reasons:—All the Australian shells I have seen from Queensland, Northern Territory and from Western Australia are short-spined shells. The Sumatra specimens and those figured by Sowerby are long-spined, two or three times as long as those from Australia. The sculpture of those from Australia is very distinct, being variously described as coalesced granules or broken wrinkles, very distinct from the widely spaced granules of the Sumatra shell, with which Sowerby's description well agrees; also, these latter have extensive encroachment of the girdle at the sutures, which is not the case with the Australian specimens. I therefore propose to adopt Pilsbry's recognition of our Australian shell as being con-specific with Blainville's *Chiton gemmatus*; but I differ from him in concluding that Sowerby's *Chiton spiniger* is the same species. I am convinced that his shell is a good species and not a synonym of *A. gemmata,* Blain. And I propose to recognise *A. spiniger,* Sow., in the shells from Sumatra.

Acanthopleura spinosa, Bruguiere (1792). *Chiton spinosus,* Brug. Jour. d'Hist. Nat., i., p. 25, t. 2, f. 1, 2 (1792). (For other references, *see* Pilsbry l.c.)

Three specimens of this species are included, marked from North Western Australia, without a number. I have also one in my

collection from the same part. These all seem to be normal shells with black, pointed spines in the girdle reaching a maximum length of 7 mm., the sculpture of the shell being confined to coarse, wrinkled growth lines. On disarticulation, the anterior valve shows long insertion plates, 13 slits, teeth deeply grooved outside, edges of teeth serrated inside and coated with a thin plate leaving only the edges of the teeth protruding. Median valve one slit, sutural laminæ very narrowly joined across the sinus, and there showing slight grooving. Posterior valve: insertion plates long, nine slits, not bent forward, almost vertical but bent slightly backwards, insertion plate deeply grooved outside, edge of teeth bluntly and irregularly serrate, quite different from the even serrations of the anterior valve. Inside of insertion plate smooth and solid, except near edge of teeth. The inside is purplish and the sutural laminæ white. The fact that the insertion plates of the tail valve do not bend forward separates this species at once from *A. gemmata*, Blain.

Acanthopleura spinosa, Brug. var. *Monte Belloensis*, n.v.

From Monte Bello Island, No. 5888, one specimen in museum collection with abnormally developed spicules; and I have also a second specimen from the same locality in my collection given me some years ago by the same Museum. Both specimens are badly curled, and therefore measurements are approximate only. The one in the Museum is 65 x 21 mm., and the other slightly smaller; the spines of the former are all more or less broken, but measure up to 14 mm.; in my specimen the spines measure 20 mm. in length, and if absolutely perfect would be slightly longer. These spines are black, solid, much curved, tapering to a point, rugosely ridged longitudinally, and some show light colour rings more or less throughout their length. The long spines are very numerous, but in between them the girdle is beset with short, blunt spines mostly under a mil. in length. These are probably modified scales and are attached to the superficial layer of the girdle, while the long spines are deep seated and look as if capable of movement from the base in the living animal.

I am treating the two specimens described as co-types. Were more available and disarticulation possible, specific differences might be recognised; but for the present it must rank as a variety only.

Liolophura georgiana, Quoy. and Gaim.

While the genus *Liolophura*, Pilsbry, is included by Dr. Thiele under the super-genus *Acanthopleura*, the absence of insertion plate in the tail valve seems to fully justify the action of Dr. Pilsbry in giving it full generic rank. See his able treatment of this group (Man. Con. Vol. XIV., p. 240).

I have always been struck with the ability of *L. georgiana* to grip the rocks and also the extremely strong attachment of the girdle to the tail valve, whereas the absence of insertion plate in that valve would lead one to expect quite otherwise.

On close examination one notices that the wide, overhanging eaves of the tegmentum in this valve are apparently coated with a thin layer of calcareous material resembling the articulamentum, and in the adult specimen perforated with numerous rather large holes.

Further, between thick tegmentum of the eaves and the thickened terminal plate of the articulamentum there is a deep fissure extending from the outer edge on each side for fully a quarter of the width of the valve, and in this deep fissure, towards its base, in the wall of the articulamentum there are present a number of laminæ. This feature is evidently a modification of the original laminated or serrated insertion plate. In a disarticulated, quarter-grown specimen from Yallingup I cannot see the perforations, which of course may be accidental in the adult, but in the juvenile the deep fissure is continuous the whole way across the valve, and while I could not see the lamina, I have no doubt they exist.

The strength of the girdle attachment of the tail valve is evidently due 1st, to the presence of the fissures; 2nd, to the laminæ at its base; and, 3rd, possibly to the perforations, the whole forming a very interesting specialised modification of the insertion plates. 10 sps. Yallingup, 2 sps. Carnac, 4 Albany No. 5818, 2 Safety Bay Nos. 243/4.

Callochiton platessa, Rottnest Is., No. 5816.

Ischnochiton torri, Ire. and May, Rottnest Is., 1 sp. No. 5818.

Ischnochiton iredalei, Dupuis; *I. lineolatus,* Bl. of Iredale and May; *I. contractus,* Rv. of Pilsbry, auct., 1 sp. 5820.

Ischnochiton, contractus, Reeve, off buoy Fremantle, 1 sp. No. 5812 = *I. decussatus,* Rv. auct.

Ischnochiton verconis, Torr. Bernier Is., Sharks Bay, 1 sp. This is the second record, and extends its range northward some 600 miles. Was omitted from my 1918 list through an oversight.

Ischnochiton virgatus, Reeve, Rat Is., Abrolhos, 3 sp., No. 4996; Cottesloe Beach, No. 7638, 7 sp.; Albany, No. 5822, 1 sp.

Ischnochiton (*Haploplax*) *resplendens,* Bed. and Mat., Yallingup 5807.

Ischnochiton (*Heterozona*) *cariosus,* Pilsbry, Bernier Is., 2 sp. 4137/8. The most northerly record, and was taken by writer at Dongara and Geraldton.

Callistochiton meridianalis, Ashby, Albany, 1 specimen, No. 5817.

Plaxiphora albida, Blainville, Ellensbrook, 1 specimen, No. 5814, Cottesloe Beach, No. 636.

Acanthochiton kimberi, Torr, Albany, 1 sp., No. 5809. Previously only recorded from Yallingup, where two sps. were taken by writer.

Acanthechiton (*Notoplax*) *sub-viridis,* Torr., Albany, 1 sp., No. 5811.

Cryptoplax striatus, Lamarck, Hopetoun, 1 sp., No. 5810.

Rhyssoplax torrianus, Hed. and Hull, Albany, 1 sp., No. 5808.

Rhyssoplax tricostalis, Pilsbry, Ellenbrook, 1 sp., No. 5814.

Acanthopleura gemmata, Blain, Monte Bello Is., 2 sp., No. 5887. Mauds' Landing, No. 9326; Bernier Is., No. 7130; Broome, No. 987.

Acanthopleura spinosa, Brug., North Western Austr., 2 sp., typical.

Acanthopleura spinosa, var. *Monte Belloensis,* Ashby, 1 sp., Monte Bello Is.

Liolophura georgiana, Blain. Before referred to.

Tonicia (*Lucilina*) *delecta,* Thiele, Bernier Is., Shark's Bay, Type Locality No. 4135, off Shell Sharks Bay, No. , Port Hedland, 1 sp., No. 8971. This specimen is a little unusual in sculpture, the dorsal and pleural areas showing parallel ribbing.

Onithochiton scholvieni, Thiele, Rottnest Is., No. 5813.

Sclerochiton curtisianus, Smith, Point Cloates, No. 9336. The entire surface of all shells is eroded, but the characters of the insertion plates and the girdle scales evidently place it in the genus *Sclerochiton,* Pilsbry. Up to the present, I have detected no character but such as is common to the shells from Port Darwin and Queensland. This is the first time representatives of this genus have been recorded from Western Australia.

Lorica cimolea, Reeve. Two worn median valves only. From Ellensbrook and Rottnest Is., No. 5818.

CONTRIBUTIONS TO THE FLORA OF WESTERN AUSTRALIA.

No. IV.

By D. A. HERBERT, M.Sc.

(*Read 13th December,* 1921.)

Darwinia thryptomenioides, sp. nov.

A shrub with slender erect virgate branches. Leaves opposite, erect, semi-terete or concave, slightly thickened upwards, obtuse, about one line long. Flowers almost sessile in the upper axils, close together so as to form an apparently terminal head of five flowers or less. Calyx tube cylindrical, turbinate, 10 ribbed; lobes semi-orbicular, under one line long fringed with spreading hairs. Petals white, orbicular, one and a-half lines in diameter. Stamens 10, one line long, alternating with flattened acuminate staminodia of the same length. Anthercells globular, the connective gland smaller. Style about a quarter of an inch long tapering upwords; stigma capitate, with spreading hairs. Ovules four, on a short lateral placenta. Seed one, Globular.

Locality—Sandplains South of Westonia.
Collectors—Herbert and Wilson, No. 110.
Date—November, 1920.

This species comes between *D. thymoides,* Benth., and the eastern *D. taxifolia,* A. Cunn., and is easily distinguished from either by the ten ribbed calyx.

Melalenca coronicarpa, sp. nov.

A straggling but rigid shrub of four feet, the young shoots pubescent. Leaves alternate, ovate-lanceolate, or lanceolate, acuminate, acute and pungent pointed, broad and rounded at the base, rigid, flat, striate, up to half an inch long. Flowers white in lateral clusters of up to 12 on a very short pubescent rachis. Calyx tube cylindrical, pubescent, about one line long, the lobes not half as long, triangular, acuminate, pubescent, with a scarious edge. Petals ovate, about a line and a-half long. Staminal bundles three to four lines

long, the claws about the same length as the petals. Fruiting calyx thick, about two lines broad, surmounted by persistent pointed woody calyx lobes.

Locality—Bruce Rock, on the road to Merredin.
Collectors—Wilson and Herbert, No. 152.
Date—November, 1920.

The species comes nearest to *M. undulata,* Benth. The name is in allusion to the appearance of the persistent calyx lobes.

Pultenaea astipulea, sp. nov.

A shrub up to two feet high with numerous erect pubescent branches arising from the base. Leaves linear oblong, obtuse, mucronate with revolute margins, pubescent on the upper surface, below, mostly two lines long, but those on the old branches up to four lines. Stipules absent. Flowers on short pedicels up to about 25 on a terminal head, surrounded by a few lanceolate acuminate bracts a little longer than a line in length. Bracteoles hairlike, hispid, about one line long. Calyx pubescent, nearly three lines long, the two upper lobes larger than the others, rounded obtuse, the others acuminate acute, as long as the tube. Standard about twice as long as the calyx, lower petals shorter. Ovary villous. Pod ovate, three lines long.

Locality—Totadgin.
Collectors—Wilson and Herbert, No. 118.
Date—November, 1920.

Pultenaea drummondii is its nearest relative.

Jacksonia hemisericea, sp. nov.

Stems erect, about one foot high, virgate, rush-like, branched, the barren branches glabrous. Flowers rather distant on pedicels of one to one and a-half lines long, the axis silky pubescent, and six to eight inches long. Bracteoles small, linear-lanceolate, below the calyx. Calyx silky-pubescent, about three and a-half inches long, the tube almost one line long, without prominent ribs. Standard large, four lines diameter, the keel shorter (about three lines). Ovary hirsute, stipitate; ovules two.

Locality—Sand plain at Merredin.
Collectors—Herbert & Wilson, No. 47.
Date—November, 1920.

This species comes near *J. restioides,* Meissn., but the silky pubescence shows an approach to the type of *J. lehmanni,* Meissn. The name is in allusion to the half sericeous appearance of the plant, owing to the almost equal numbers of silky pubescent flowering branches and glabrous barren ones.

RUTACEAE.

Microcybe pauciflora, Turcz, var. *uniflora,* var. nov.

Glabrous variety with one flower in the head; petals slightly over one and a-half lines long. Flowering in November.

Locality—Sand plain at Westonia.
Collectors—Herbert & Wilson, No. 111.
Date of collection—November, 1920.

Daviesia uniflora, sp. nov.

A shrub two feet in height, the branches hirsute with soft spreading hairs. Leaves rather crowded, ⅜in. or less in length, obtuse with a pungent point up to a line long, marginate, the margins and the prominent midrib of the lower side, and the lamina of the young leaves bearing spreading hairs. Peduncles slender, glabrous, shorter than the leaves except at the tips where the leaves are smaller, and bearing one pedicillate flower. Bracts small. Pedicels about a quarter of an inch long. Calyx one and a-half lines long, glabrous, the teeth shorter than the tube, the two upper ones united. Standard about twice as long as the calyx. Keel nearly as long. Pod half an inch long, slightly more than three lines broad, and acuminate.

Locality—Yoting, in sand plain.
Collectors—Herbert & Wilson, No. 174.
Date—November, 1920.

This species resembles *D. mollis* in the shape of the leaves, but differs chiefly in the one-flowered inflorescence. It does not fall under any of the series proposed by Bentham, unless it be regarded as a member of the Umbellatae with the umbels reduced to a single flower.

Simsia latifolia, R. Br. (*Stirlingia latifolia,* Steud; *Simsia latifolia, var. gracilis,* Ostf.).

Bentham (*Flora australiensis,* V. 358) noted the great variation in ramification, size and breadth of the leaf segments and the size of the flowers in this species, there described under *Stirlingia latifolia,* Steud. C. H. Ostenfeld (Contributions to Western Australian Botany, Part III., in Det. Kgl., Danske Videnskabernes Selskab, Biologiske Meddelelser III., 2, 1921, p. 50) has proposed a new variety (var. *gracilis,* Ostf.) for the narrow-leafed form. The specimens on which this is founded are from the Swan River: Preiss (1839), No. 767; Cecil Andrews (1901), No. 751; Ostenfeld (1914), No. 681; and a specimen without a collector's name is at Kew from the Swan

River Colony (1842). Ostenfeld shows photographs of his type from King's Park. It is the common form, but all stages intermediate between this and the typical broad-leaved form are to be found, often on the same bush. The simpler panicle is also very variable, and is not constant for the narrow-leaved forms. Occasionally it is almost twining. The variety *gracilis* of Ostenfeld, in view of these facts, is not strong enough to be regarded as a district variety. The name *latifolia* is not an appropriate one, as the narrow-leaved forms are more common in some localities than the typical form. As a plant becomes older and weaker, it frequently becomes more straggling, and the leaves become narrower. When crushed, the leaves have a very distinct odour, which Mr. Marr, of Perth, has proved to be due to the presence of acetophenone.

Logania tortuosa, sp. nov.

A shrub of about six inches with glabrous tortuous branches, the branches opposite, or in threes, terete and rush-like, faintly sulcate. Leaves minute, scale-like. Flowers solitary and opposite in the upper axils, the pedicels about one line long. Calyx segments acuminate, acute, minutely ciliate, and a little over a line long. Corolla campanulate, pubescent, the tube shorter than the calyx segments, the lobes one and a-half lines long, very spreading. Stamens inserted in the sinus of the lobes, the anthers oblong. Ovary sparingly covered with glanular hairs, the stigma ovoid-oblong.

Locality—Sandplain, Yoting.
Collectors—Herbert & Wilson, No. 162.
Date—November, 1920.

Logania tortuosa comes between *L. nuda,* F. v. M., which it resembles in habit, and *L. spermacocea,* F. v. M. The name refers to the tortuous branches.

Gastrolobium spinosum, Benth., "Prickly Poison."

This is the commonest species of Gastrolobium in the South-West and shows considerable variation. Bentham describes it as a shrub of two to four feet, but it often attains 10 or 12 feet, as at Toodyay, Kelmscott and elsewhere. Five varieties have been proposed, most of them based on the shape of the leaves:

var. *triangulare,* Benth.—Leaves triangular cordate, quite entire with pungent points at the angles. Flowers smaller, the racemes looser and more pedunculate.

var. *angustum,* E. Pritzel.—Leaves narrow, triangular, three to five-toothed, about 12 x 35 mm.

var. *microphyllum,* Spencer Moore.—Leaves small, lanceolate hastate, the lateral lobes rounded and unarmed or provided with a weak spine; 14-17 mm. long, 5-7mm. broad close to the base.

var. *inerme,* Spencer Moore.—Leaves cordate-lanceolate, quite entire, 20-25 mm. long, 10-12 mm. broad.

var. *trilobum,* Spencer Moore.—Leaves small, broadly ovate-cordate three- (or very rarely five-) lobed, the lobes extended into a rigid spine, about 14 x 13 mm.

These varieties depend mainly on the size of the leaves, a very unsound character for so variable a species as *Gastrolobium spinosum.* It is only by a field study of the plants that the true value of the different forms can be ascertained. With the exception of var. *triangulare* and var. *trilobum,* the forms shade into one another so imperceptibly that they cannot be regarded as varieties. Often two forms may be found on the same bush. For example, in a specimen collected by E. Kelso, in the Coolgardie district in 1902, the leaves on some of the twigs have the leaves described for var. *microphyllum,* while twigs not six inches below have the characters assigned to var. *angustum,* and the narrow type of leaf is common on the same bushes as the typical cordate type.

Two varieties, var. *triangulare,* and var *trilobum,* are sufficiently well defined to be retained, but in view of their variability and their gradual merging into one another, the others must be included as forms of the typical species and not as varieties. Four forms are proposed:

1. *typicum.*—This is the typical form of the Darling Ranges. It sometimes reaches about 12 feet in height, and has leaves, on an average, one inch broad at the base and one inch long, but they may be three inches each way in luxuriant specimens (Boyanup, J. Simmons, 1919), or much smaller in stunted specimens.

2. *Angustum* (including var. *angustum,* E. Pritzel).—The plants are rather lower in stature than forma *typicum,* and the leaves narrower, generally one-two inches long by half-one inch bread. Pritzel's variety is based on specimens with leaves "narrow, triangular, three to five-toothed." The common examples are about half inch by one and a-quarter inches, and one to five-toothed. They may, however, be unarmed (Wagin, E. C. Leggo, 1921). This form passes on the one hand into forma *typicum,* and on the other into forma *parvifolium.*

3. *parvifolium* (including var. *inerme* and var. *microphyllum*).—This includes the forms with leaves smaller than those of *F. angustum.* They vary in shape from lanceolate hastate to lanceolate cordate, and in size from quarter of an inch broad by half an inch long, to half an inch broad and nearly one inch long. It passes into *F. angustum* through spiny-leaved forms (*e.g.,* Coolgardie, E. Kelso, 1902; Woodanilling, Fidock, 1916; Wagin, H. Stewart, 1916).

4. *crassifolium*.—A thick-leaved form almost worthy of varietal rank but passing through transitional forms to the typical one. Herbarium specimens appear quite distinct. Leaves up to one and three-quarter inches long and the same width at the base, cordate, entire, undulate, or with one to three spines, glaucous. This grows on sand plains in the Eastern Wheat Belt, and is generally known as "Blue Bush Poison" on account of its bluish-grey colour. The pods are rather larger than in the ordinary form (Pingelly, Geo. Walton, 1899; Lomos, Dyer, 1916; Yoting, Herbert & Wilson, 1920).

var. *triangulare*, Benth.—One specimen in the herbarium from Northam collected by J. H. Gregory in 1901 contains two twigs, one with the leaves of var. *triangulare* (but more glaucous than usual), and the other with leaves of *F. typicum* but approaching *angustum*. If these came from the same bush then the variety is not a good one, but this is not certain. Another specimen is from Northampton (Irwin District), collected in 1906, and labelled by Dr. Morrison, but without a collector's name.

var. *trilobum*, Spencer Moore (Journ. Linn. Soc. XLV. (1920), p. 170).—The type comes from Kauring (near Greenhills). There is a specimen in the herbarium from Wyalcatchem from "an exceedingly dense shrub about two or three feet, glaucous or nearly white, growing in stony ground." (C. A. Gardner, 21/8/20).

Gastrolobium spinosum is evidently evolving along three main lines. The narrow-leaved modifications have produced *angustum* and *parvifolium* successively; reduction of spines has produced var. *triangulare*, and further reduction of leaf surface and a larger development of the three spines has produced var. *trilobum*.

On the sand plains a different type has evolved in *F. crassifolium* where xerophytic adaptation has taken the form of development of thick glaucous and frequently unarmed leaves, but without reduction of size.

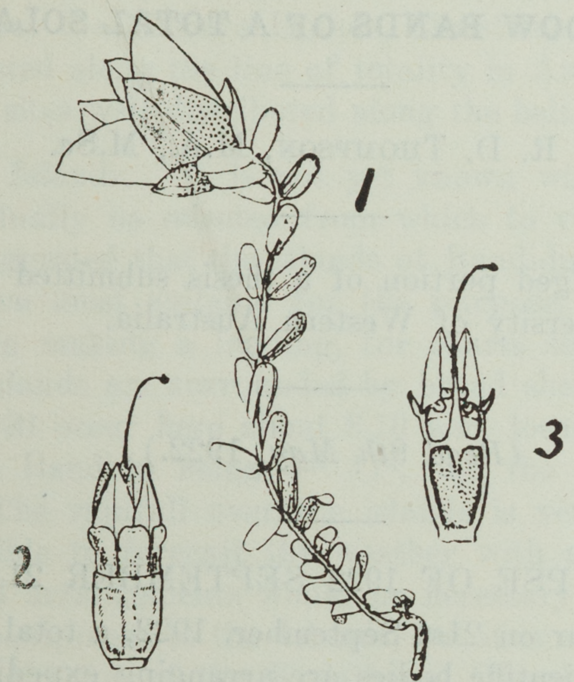
DARWINIA PIMELIOIDES, N. SP.

By A. Cayzer and F. W. Wakefield.

Presented and read by D. A. Herbert on 13th December, 1921.

Frutex parvus, ramulis multis gracilibusque et foliis oppositis. Folia subsessilia, late oblonga, convexa, 4–6 mm. longa, 2–3 mm. lata. Flores sessiles, plerumque 4 in capitula. Bracteae internae

fere 15mm. longae et 5-7 mm. latae. Calyx 5 mm. longus, tubus quinque-costatus, lobis 1 mm. longis. Stamina et staminodia breviora quam 1 mm. Petala circiter 2.5 mm. longa. Stylus praelongus.



DARWINIA PIMELIOIDES.

1. Leaves and inflorescence.
2. Flower,
3. Longitudinal section of flower.

A small shrub, 25 cm. to about 1 m. high, glabrous, with numerous slender branches; branchlets usually slightly angular and coloured. Leaves opposite, spreading, subsessile, broad-oblong, convex, with recurved margins, obtuse, 4–6 mm. long. Flower heads terminal, nodding, usually with 4 flowers. Involucral bracts 6, the 3 outer ones purplish-red, ovate, the 3 inner yellowish-green, ovate-lanceolate, about 15 mm. long. Calyx about 4 mm. long, the adnate part 5-ribbed, the lobes less than 1 mm. long. Petals ovate-lanceolate, about 2.5 mm. long. Stamens and staminodia shorter than the petals. Style exserted, hooked at the end.

Habitat—Red Hill, near Midland Junction, West Australia. Collected 5/10/18.

THE TOTAL SOLAR ECLIPSE OF 1922 SEPTEMBER 21, TOGETHER WITH A DISCUSSION AS TO THE ORIGIN OF THE SHADOW BANDS OF A TOTAL SOLAR ECLIPSE.

By R. D. THOMPSON, M.A., M.Sc.

Being an abridged portion of a thesis submitted for the M.Sc. degree in the University of Western Australia.

(*Read 9th May,* 1922.)

ECLIPSE OF 1922 SEPTEMBER 21.

There will occur on 21st September, 1922, a total eclipse of the sun, and various scientific bodies are arranging expeditions in order to view the eclipse at several points along the narrow belt of totality. In addition to the general observation and investigation of phenomena associated with a total solar eclipse, much attention will be devoted to obtaining further evidence of the so-called "Einstein effect," *i.e.* the apparent displacement of stars near the sun's limb due to the deflection of light rays in passing through the gravitational field of the sun. The deflection to be expected according to the Einstein Relativity Theory of Gravitation is just double that given by the Newtonian Theory, but in no case does the apparent angular displacement exceed two seconds of arc, so that extreme precision in measurement is essential. In fact, the actual displacements to be measured on a photographic plate are only about one-thousandth of an inch.

The total phase of the eclipse occurs at sunrise at a point in Abyssinia near the north-east coast of Africa, the belt of totality then leaving Africa at Somaliland, passing eastwards across the Indian Ocean, and cutting through the Maldive Islands. From there the line of totality gradually assumes a more southerly trend, moving in an E.S.E. direction to Christmas Island, where the eclipse occurs at very near noon, and then to the north-west coast of Australia, entering Australia towards the southern end of the Ninety Mile Beach. The line, then bending slightly more to the east again, crosses Australia almost centrally, finally leaving the continent just to the south of Brisbane. The total phase of the eclipse occurs at sunset at a point to the north of New Zealand.

Thus it will be seen that practically the only land areas from which the total eclipse is visible are the north-east coast of Africa, certain of the Maldive Islands, Christmas Island, and the continent of Australia. At the former the eclipse occurs while the sun is still very near the horizon, and is therefore of little value for observational work, but the Maldive Islands, Christmas Island, and various localities selected along the line of totality in Australia, will provide observational sites well distributed along the belt.

Maldive Islands. It is not yet known which of the Maldive Islands will finally be selected from which to view the eclipse, but it has been suggested that the islands of Bandidu or Dambidu would probably prove most suitable for the purpose. Difficulty may be encountered in making a landing, for charts seem to indicate that most of the islands are surrounded by broad shelving reefs of coral. The eclipse will occur here about 8.10 a.m. local time, the duration of totality at Bandidu being 4^m 11^s, and the altitude of the sun about 34°. The rainfall over the islands is very irregular, and it seems impossible to forecast the weather with any degree of accuracy. Special arrangements would be necessary in order to convey a party and equipment to the Islands, but it is understood that Mr. J. Evershed, director of the Kodaikanal Observatory (India), will occupy one of the islands, where no doubt his work will include an extended series of spectroscopic observations.

Christmas Island. The eclipse occurs here at almost local noon, when the sun at an altitude of 78° is well up towards the zenith, and therefore in a position eminently suitable for photographic work. Unfortunately Christmas Island lies about 55 miles from the central line of the eclipse; in fact, it is only a little more than 10 miles within the line of the northern limit, and thus the duration of totality will be comparatively short, viz. about 3^m 17^s. The island suffers from a heavy and irregular rainfall, although September is probably the most favourable time of the year so far as weather prospects are concerned.

The British Joint Permanent Eclipse Committee has decided to occupy this island, and Mr. H. Spenser Jones and Mr. P. J. Melotte left England in February for Singapore, whence they were to be conveyed to the island in one of the Christmas Island Phosphate Company's steamers. This party will be concerned chiefly in making further determinations of the deflection of light in the gravitational field of the sun, and a 13-inch astrographic telescope, equatorially mounted, will form part of the equipment. As this instrument should be erected by May, several months will be spent in carrying out an extensive programme of photometric work with a view to standardising the photographic scales of stellar magnitude for the southern hemisphere with those of the northern. Thus even

if unfavourable weather should prevail at the time of the eclipse, highly important results will yet have been obtained.

In addition to the British party, it is believed that a joint Dutch and German expedition under Prof. Voûte, of Batavia University, and Prof. Freundlich, of Germany, will also visit Christmas Island. It is possible that the personnel of this latter party will include Prof. Einstein himself.

Wallal, W.A.[1] The moon's shadow will reach Australia towards the southern end of the Ninety Mile Beach, and this region undoubtedly affords highly favourable opportunities for viewing the eclipse. Wallal, where there is a telegraph station, is only 2½ miles from the central line of the eclipse, the width of the belt of totality being about 135 miles. The entire district is one of low, rolling sand dunes, and no difficulty would be experienced in selecting an observational site almost exactly on the central line, thus securing the maximum period of totality. The weather prospects for Wallal are exceptionally good; in fact, the average rainfall on the Ninety Mile Beach for the months of August, September and October does not exceed 0.06 inches in any one month.

The Circumstances of the eclipse at Wallal (lat. 19° 46′ S., long. 120° 41′ E.) are as follows:—

		W.A. Standard Time.			
		h.	m.	s.	
First Contact	21st Sept.	0	3	11·0	p.m.
Second Contact	”	1	27	21·9	p.m.
Greatest Phase	”	1	30	1·3	p.m.
Third Contact	”	1	32	40·7	p.m.
Fourth Contact	”	2	49	54·2	p.m.

Duration of Total Phase: 5^m $18{\cdot}8^s$

Altitude of Sun at time of Greatest Phase: 58°

Angle from North Point of First Contact: 299½°

Angle from North Point of Last Contact: 117°

Angle from Vertex of First Contact: 129°

Angle from Vertex of Last Contact: 359°

An expedition from the Lick Observatory, California, under the direction of Prof. W. W. Campbell, the director of the Observatory, will occupy Wallal, and Dr. Adams, Government Astronomer of New Zealand, and Prof. A. D. Ross, of the University of Western Australia, will be included in the party. The members of the expedition are to be the guests of the Commonwealth Government, and the Naval Department is making all arrangements for transport,

[1] The advantages of Wallal as an observational site have been pointed out in a paper by Prof. Ross and the writer. (See *Monthly Notices* of the R.A.S., LXXXI., 3.)

etc. The party will journey to Broome by the s.s. "Charon" (sailing about 20th August), whence a small schooner has been chartered for the run to Wallal (about 200 miles). The schooner can easily beach with the tide at a point opposite Wallal, and on account of the large rise and fall of tide (28 feet at springs), waggons or bullock drays may be drawn alongside the vessel when the water recedes, and stores and equipment thus landed. No doubt assistance could be obtained from the Wallal Downs sheep station, situated within four miles from the telegraph station. The party will live under canvas, and there is an abundant supply of good fresh water.

It is understood that a local party, under the direction of Mr. Nossiter, Chief Assistant at the Perth Observatory, will also occupy a station near Wallal.

Central and Eastern Australia. The belt of totality passes across the top north-eastern corner of South Australia, and an expedition from Adelaide will observe the eclipse from Cordillo Downs station, situated in this region. The party will travel to Farina by rail, whence the journey to Cordillo Downs will take some five or six weeks by camel transport. The eclipse occurs here shortly after 3 p.m. local time, the duration of totality being about four minutes.

Farther to the east, Cunnamulla and Coongoola, Goondiwindi, Stanthorpe, and Casino are crossed in turn by the moon's shadow. Cunnamulla and Coongoola are on the same line of railway, Coongoola being almost in the centre of the belt, while Cunnamulla is some 30 miles therefrom. The total phase at these two stations occurs at about 4 p.m. local time, the sun's altitude being about 26°, and the duration of totality at Coongoola 3¾ minutes. On account of their comparative isolation there would be considerable difficulty in obtaining stores and assistance; and in dry weather the dust is usually a source of great discomfort.

At Goondiwindi and Stanthorpe, almost exactly on the central line, there would be no difficulty in obtaining stores and assistance, while electric power is also available. Both stations would furnish good observing sites and accommodation. It is understood that several expeditions from the Eastern States have decided to observe the eclipse from Goondiwindi.

Casino, in New South Wales, is only about 30 miles from the coast, and being in the centre of the tourist region is easily accessible. But the astronomical conditions are of course greatly inferior to those stations farther west. The total phase will occur at about 4·30 p.m. local time, when the sun will be very near the horizon.

The chances of rain are not great at any place along the line of totality in Australia, but cloudy weather is the more likely to be

met with the nearer the eastern coast is approached. But there would appear to be little doubt that the attractions of any station to the east are considerably less than those possessed by Wallal, on the north-west coast, where the weather prospects are excellent and the astronomical conditions eminently favourable. In fact, it seems highly likely that the advantages offered by Wallal are superior, not only to those of any other station in Australia, but to those offered anywhere along the whole length of the line of totality.

SHADOW BANDS.

One of the most interesting phenomena associated with a total solar eclipse is that of the "Shadow Bands." These are long, tremulous bands of alternate light and shade, which sweep across the landscape just before and after totality. They are usually ill-defined, faint and hazy, resembling in structure the shadows cast by ripples of water on the sand beneath. A completely total eclipse is not necessary for their production, for they appear to have been first recorded at the annular eclipse of 1820, and subsequently, in the eclipse of 1870, they were observed in a region just outside the zone of totality.

As might be expected from the ill-defined nature of the shadow bands, accurate observation of them is exceedingly difficult, and no doubt accounts in a large part for the great differences and apparent contradictions in the reports which have been made of them. Some observers have noted them simply on the ground or the deck of a ship; others have seen them on a white sheet spread on the ground or on a white vertical wall; while by far the most complete equipment for their observation seems to have been prepared by Dr. M. Roso de Luna during the eclipse of 1905 at Soria (Spain), an equipment consisting of no less than six screens placed in certain definite positions.[1]

It has been suggested that the existence of these bands may be due to the optical phenomenon of diffraction, the narrow illuminated crescent of the sun just before and after totality acting as the source of light, and the dark limb of the moon being regarded as equivalent to the diffracting edge. Upon critical examination, however, this theory offers so many objections, that it may certainly be discarded. According to the diffraction hypothesis, the bands should form a regular, set pattern surrounding the moon's shadow, the form of this pattern being determined by the optical laws of diffraction. The speed of the bands across the earth's surface should, therefore, be the same as that of the main shadow. Now the minimum speed of the

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1. *Astronomische Nachrichten* 4086.

umbra is 24 miles a minute, whereas in no case have the shadow bands been observed to travel at a speed greater than one-fifth of a mile per minute; in fact, in the majority of cases the recorded speed is much less than this. Further, the direction of motion of the bands should always be the same as that of the main shadow, but this is by no means invariably found to be the case. In fact, the direction of motion before totality is not always the same as after totality, while on at least two occasions[1] two sets of bands have been simultaneously observed moving in opposition directions. This cannot be explained on the diffraction hypothesis.

Again, assuming a case of diffraction at a "straight edge," *i.e.*, that the small portion of the lunar arc visible against the bright background of the sun is straight, a simple calculation will show that three minutes before totality (the average time at which shadow bands become visible), there should be no less than some 58,000,000 bands between the observing station and the advancing edge of the main shadow. Even assuming that the bands were evenly spaced in this interval, this would give the distance from band to band as only 0.08 inches, but the bands should actually become broader and more widely spaced as the main shadow approaches, so that three minutes before totality they would appear even closer together. Practically all observers agree, however, that the actual distance apart of the bands is from two to four inches, a result incompatible with that deduced from the diffraction theory. The calculation yielding the figures quoted above is made on the assumption that the bright crescent of the sun acts as a linear or "slit" source of light, an assumption which may perhaps be questioned in view of the appreciable width of the sun's crescent. But the diffraction pattern should be quite independent of the size of the slit, except that if the slit becomes too wide the diffraction bands become so blurred as to be indistinguishable.

Another theory which has been advanced to account for the existence of shadow bands claims that these bands are the result of purely local atmospheric conditions, and are not in any way attributable to the peculiar circumstances of an eclipse, except that during an eclipse the illuminated disc of the sun is reduced to a comparatively narrow slit or band. The relative movement between two layers of air at different densities would produce ripples at their common surface, causing unequal refraction and dispersion of the light rays, and consequently shadow images of these ripples would be thrown on the surface of the earth in the same manner as ripples on the surface of water cast shadows on the sand beneath. There seems no reason to doubt that such wavelets or "ripplings" would be produced in the atmosphere, and although the ripplings as shown

1. *The Total Solar Eclipse of May, 1900 (B.A.A.), p. 166.*
The Total Solar Eclipse, 1905 (B.A.A.), p. 51.

by the clouds seem to be larger than those pictured by the shadow bands, it is highly probable that waves and ripples of all sizes are present in the atmosphere. The larger waves would no doubt give rise to shadow images so diffused and blurred as to be quite imperceptible, and thus these shadow images or bands would appear never to exceed a certain size. In fact, the larger and broader the bands, the fainter and less well defined one would expect them to be, and on the whole this seems to be borne out by the evidence of observers.

These shadow images of atmospheric ripples would be produced only when the source of light was of comparatively small dimensions, such as the narrow crescent on the sun's disc when an eclipse is near totality, for with the light coming from such an extended source as the whole of the sun's disc, the shadows would be blurred and indistinguishable. In fact, the most favourable circumstance for the production of these shadow images is when the ripples of air are parallel to the illuminated crescent of the sun, and the greater the angle between the lengthwise direction of the ripples and the line of the crescent, the fainter and less well defined would the shadows be. This then affords a feasible explanation of the fact that at some localities during an eclipse no shadow bands have been observed at all; either there were no atmospheric ripples of the right magnitude to produce images, or, what is more likely, the ripplings were not sufficiently in line with the narrow crescent of the sun.

The actual direction of motion of the shadow bands would be determined by the direction of the air current producing the atmospheric ripplings; in general, these two directions would be the same. If, however, the ripplings were caused by two consecutive strata of air, both in motion, then the direction of the ripples would be determined by the relative direction of motion of the strata, and need not be the same as that of either one. Further, it must be noted that these air currents or "drifts" may be at some height above the surface of the earth, and, therefore, need by no means be in the same direction as the wind, thus accounting for the variation often observed between the direction of the wind and the direction of the shadow bands. Again, there is no reason why the direction of the atmospheric drift should not sometimes change during totality, and thus the direction of the bands might appear reversed after totality. Moreover, there may be two or more quite distinct drifts, each giving rise to atmospheric ripplings, and thus explaining the two distinct sets of bands seen simultaneously. Finally, this hypothesis serves to explain a rather curious fact observed during the eclipses of 1900 and 1905, viz., that the "whole set of moving lines was also moving" in a perfectly definite direction.[1] Could not the air drift giving rise to the bands itself form part of a larger body of air which was also in motion? This would account satisfactorily for the appearance described.

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1. The Total Solar Eclipse, 1905. (B. A. A.), p. 52.

It is interesting to note that shadow bands, similar in every way to those of a total eclipse, have been observed at sunrise and sunset, when owing to the intervention of a distant hilltop, only a small portion of the sun's disc has been visible.[1] The reduced source of light necessary for the production of shadow bands is thus obtained. As the result of a remarkable series of observations made at Aoste (Italy), during the years 1905-1906, M.Cl. Rozet has not only fully identified the shadow bands of sunrise and sunset with those of a solar eclipse, but has also shown that the general character of the bands is intimately associated with atmospheric conditions.[2] Further, M. Rozet has succeeded in obtaining shadow bands with the planets Venus, Jupiter, Mercury, and with several of the brighter stars.[3]

Thus it would appear that the weight of evidence strongly supports the theory that the shadow bands of a total eclipse are the result of local atmospheric conditions, and probably the most useful line of research would be that instituted by Miss C. O. Stevens,[4] viz., the accurate determination of the atmospheric drift both up to and after totality.

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1. *Monthly Notices* of the R.A.S., XL. 5.
2. *Comptes Rendus*, CXLII., p. 913 (1906)
3. *Comptes Rendus*, CXLVI., p. 326 (1908)
4. *The Journal of the B.A.A.*, XVI., 2.

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